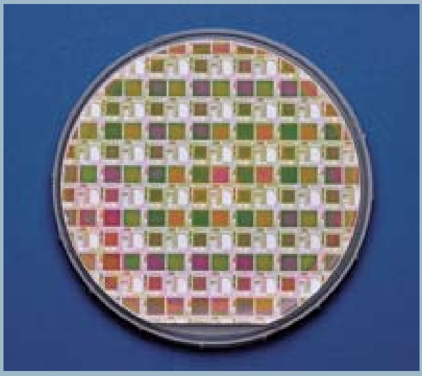
MIT LINCOLN LABORATORY

2008 ANNUAL REPORT



TECHNOLOGY IN SUPPORT OF NATIONAL SECURITY

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Massachusetts Institute of Technology

MIT Lincoln Laboratory

MIT LINCOLN LABORATORY

2008

MISSION:

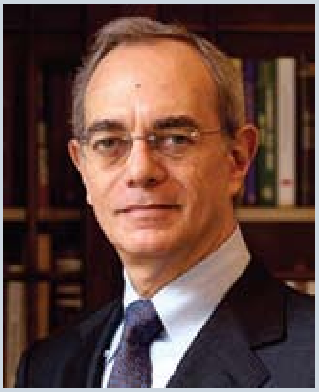
TECHNOLOGY IN SUPPORT OF NATIONAL SECURITY

MIT Lincoln Laboratory employs some of the nation's best technical talent to support system and technology development for our national security needs. Principal core competencies are sensors, information extraction (signal processing and embedded computing), and communications. Nearly all of the Lincoln Laboratory efforts are housed at the Hanscom Air Force Base complex in Massachusetts.

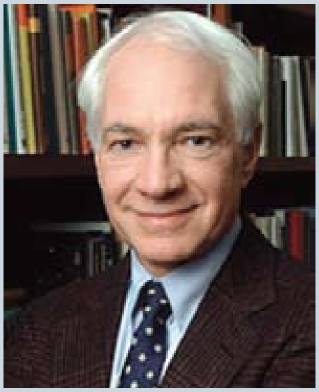
MIT Lincoln Laboratory is designated a Department of Defense (DoD) Federally Funded Research and Development Center (FFRDC) and a "DoD Research and Development Laboratory." The Laboratory conducts research and development pertinent to national defense on behalf of the Military Services, the Office of the Secretary of Defense, the Intelligence Community, and other government agencies. Projects undertaken by Lincoln Laboratory focus on the development and prototyping of new technologies and capabilities for which the government cannot rely on in-house or private-sector resources. Program activities extend from fundamental investigations through design and field testing of prototype systems using new technologies. A strong emphasis is placed on the transition of systems and technology to the private sector. The Laboratory celebrated its 50th anniversary of service to the nation and received the Secretary of Defense Medal for Outstanding Public Service in recognition of a half-century of distinguished technical innovation and scientific discoveries.

Massachusetts Institute of Technology

Dr. Susan Hockfield
President

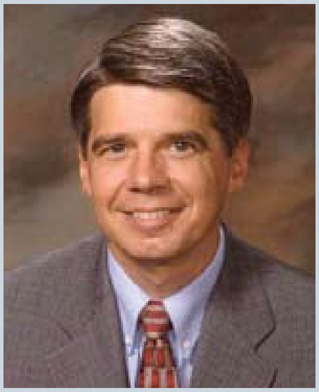


Dr. L. Rafael Reif
Provost



Dr. Claude R. Canizares
Vice President for Research and Associate Provost

MIT Lincoln Laboratory



Dr. Eric D. Evans
Director

Dr. Antonio F. Pensa
Assistant Director

Mr. Lee O. Upton
Assistant Director

Mr. Anthony P. Sharon
Chief Operating Officer

LETTER from the Director of MIT Lincoln Laboratory

Lincoln Laboratory's reputation has been built on the strength and quality of its technical staff. As we approach six decades of service to the nation, I am pleased to report that the staff continues to carry on the Laboratory's legacy of technical excellence, innovation, and integrity. The Laboratory is operating near peak levels and continues to develop advanced technology solutions for many of the nation's most complex national security problems.

This report highlights Laboratory accomplishments for the past year, including new work in homeland protection, counterterrorism, and network-centric sensor systems. The Laboratory is also beginning initiatives in the areas of disaster relief, environmental sensing, and energy technology. As the Laboratory's strong national security programs evolve, we are continuing to leverage defense technology to support nondefense national needs.

As in the past, current Lincoln Laboratory programs include a significant level of system analysis, prototype hardware and software development, and field testing. Laboratory work reaching significant technical milestones this year include:

- Extended Space Sensors Architecture program for net-centric integration of space situational awareness sensors
- XTR-1 mobile X-band instrumentation radar for supporting the Missile Defense Agency's mobile range concept
- High-data-rate, optical free-space communications systems with efficiencies of greater than 1 bit per photon
- 3-D laser detection and ranging prototypes for advanced ground surveillance
- New superconducting qubit demonstrations for advanced quantum computing
- Wideband signal intelligence receivers for counterterrorism applications
- Corridor Integrated Weather System and Runway Status Lights system enhancements for the FAA
- Enhanced Regional Situation Awareness system improvements for homeland air defense of the National Capital Region
- Fifty years of Ballistic Missile Defense (BMD) work
- Thirtieth anniversary of the Air Vehicle Survivability program

Also during the past year, we have continued to expand the Lincoln Laboratory Community Outreach program for community service and education. We have increased our education support to local schools through our Science on Saturday, teacher externship, and seminar outreach programs. We are continuing to improve Laboratory diversity and the overall work environment through improvements to our college recruiting, staff development, and flexible work policies. We have recently begun a conservation initiative to reduce the Laboratory's energy use and improve its recycling program.

We are also pleased to report that collaborative initiatives between MIT campus and Lincoln Laboratory are at an all-time high. These collaborations are important for enhancing the development of innovative concepts and technology. The Laboratory has begun a new fellowship program for MIT graduate study and is supporting joint research through over twenty-five research assistantships. Our relationship with MIT is central to our Laboratory culture.

We encourage you to review this annual report for a better understanding of the Laboratory's core missions and accomplishments. We are looking forward to the future as we continue our strong commitment to developing technology in support of national security.

Sincerely,

Eric D. Evans

Eric D. Evans
Director

Lincoln Laboratory Strategic Directions

Strategic directions for Lincoln Laboratory are based on a Director's Office and senior management update of the Laboratory's strategic plan and a review of national-level studies, such as the National Defense Strategy, the Quadrennial Defense Review, and recent Defense Science Board recommendations.

- **Identify new mission areas, based on current and emerging national security needs**
- **Strengthen and evolve the current Laboratory mission areas**
- **Strengthen the core technology programs**
- **Increase MIT campus/Lincoln Laboratory collaboration**
- **Strengthen technology transfer to acquisition and user communities**
- **Increase outside connectivity and communications**
- **Improve Laboratory diversity**
- **Expand community outreach and education**
- **Continue improving Laboratory engineering services, administration, and infrastructure**

Lincoln Laboratory's Millstone Radar is a high-power, L-band radar used for tracking space vehicles and space debris. Millstone provides 50,000 deep-space satellite observations a year, making it a key contributor to the national deep-space surveillance program.

NEW MANAGERS

Mr. Joseph M. Flynn
Chief Information Officer

Chief Information Officer

Mr. Joseph M. Flynn joined Lincoln Laboratory in 2007 to lead the Information Services Department (ISD). The ISD is responsible for providing central information technology (IT) services for the Laboratory. The department integrates research and enterprise service information technologies to meet the evolving requirements of the Laboratory and its sponsors. The ISD is customer-focused, providing high-value, cost-effective IT solutions and services that establish a secure and stable infrastructure as the foundation of research, administration, security, and mission assurance.

Mr. William Kindred
Manager, Diversity and Inclusion

Manager, Diversity and Inclusion

Mr. William Kindred joined the Laboratory's Human Resources Department as Manager, Diversity and Inclusion, in May 2008. In this role, Mr. Kindred works to enhance ongoing recruiting efforts to increase the representation of under-represented groups at the Laboratory. Additionally, he will identify and recommend training programs that support the Laboratory's continuing commitment to an inclusive and diverse work environment. Mr. Kindred focuses on building both external and internal relationships that align with the Laboratory's high-priority diversity initiatives.

Chief Technology Office

Members of the Chief Technology Office (from left to right) are Randy Avent, Bill Keicher, Zach Lemnios (Chief Technology Officer), Ken Senne, and Howie Shrobe.

The MIT Lincoln Laboratory Chief Technology Office (CTO) is responsible for coordinating technology strategy across the Laboratory and for establishing and growing strategic technical relationships outside of the Laboratory to support current and future Laboratory missions. The CTO works closely with senior management and all Laboratory divisions to drive the overall strategic and technical direction of the enterprise.

This past year, the CTO extended the Laboratory's technology position in advanced electronics, biological-chemical sensing, photonics/single-photon communications, and ISR sensing/decision support. Prior technology investments have matured into system concepts with transitions to a broad sponsor and user base.

The Laboratory's work in avalanche photodiode (APD) technology is an example of early investments that are beginning to transition. Initial work in this area was focused on materials growth and device fabrication. Work has been extended to large-area arrays of single-photon-counting detectors that have become the foundation of new communications, 3-D imaging, and foliage penetration concepts.

Many projects include significant collaborations with research groups at MIT and other leading universities. These interactions have provided application pull for campus research and have extended the Laboratory's technology reach in new areas. In 2008, new collaborations were launched with MIT research groups in autonomous sensing and robotics, social network analysis, decision support, and network coding for adaptive systems. In addition, the CTO launches a range of additional technology seedling efforts throughout the year to encourage technology-driven innovations.

The Laboratory's technology investments have enabled a set of new mission concept demonstrations in the homeland protection, net-centric operations, and counterterrorism/counterinsurgency areas. These projects integrate and validate advanced technology concepts through field tests and end-to-end demonstrations.

Safety and Mission Assurance Office

Jim Wade (right), leader of the Safety and Mission Assurance Office, reviews program details with his staff.

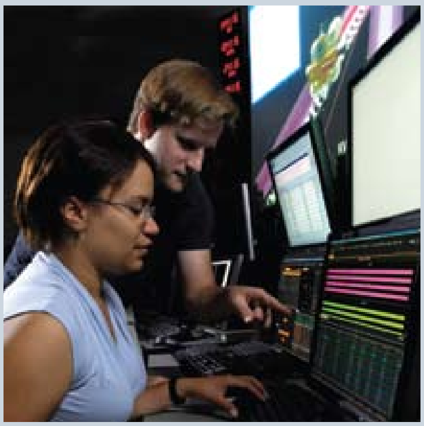
The Safety and Mission Assurance Office develops and implements policies and procedures to help assure that large-scale programs succeed. Over the past year, the Office developed a comprehensive Quality Management System (QMS) that provides a mechanism for continually improving systems and services. The goal is for major projects (typically space and missile systems) to attain compliance with the AS9100B quality standard. The QMS comprises guiding policies and procedures that formalize processes and provide rigor to quality, engineering fabrication, safety, procurement, and program management. The Office also enabled process improvement through a number of mechanisms.

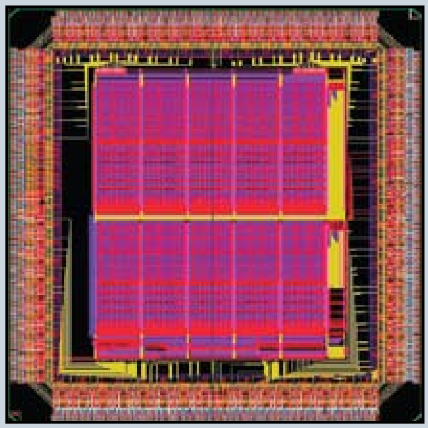
The Office collaborates with each program manager to tailor a mission assurance plan that defines specific processes to be implemented. It assigns a mission assurance engineer to the program to perform program-specific mission assurance and analyses. Working closely with the Engineering Division, the Office defines requirements, inspections, calibration, process definition (such as electrostatic discharge), and process improvements.

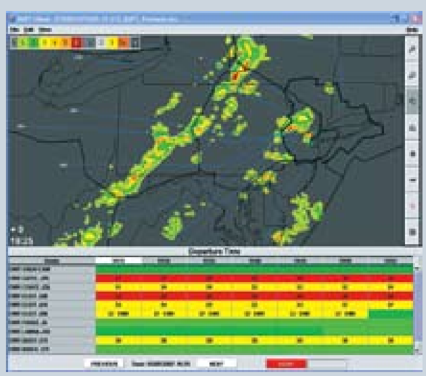
Quality begins early in the supply chain, so the Office collaborates with procurement staff to define procedures to guarantee goods and services meet quality and service standards. An Approved Supplier List and a supplier "report card" were developed to assure that suppliers chosen for projects are capable of meeting requisite standards. The report card provides for Laboratory-wide sharing of experiences regarding specific suppliers.

In the past year, the Office sponsored internal and external audits that evaluated the Laboratory's progress toward AS9100 compliance. The findings from these audits identified that significant improvement has been made and provided direction for future initiatives.

A recent merger of the Mission Assurance Office with the Laboratory's Environmental, Health, and Safety (EHS) Office integrated the system safety components of mission assurance with the Laboratory's environmental and safety support services. Implementation of the EHS Management System was initiated in order to meet compliance with governmental regulations.






Departure Time

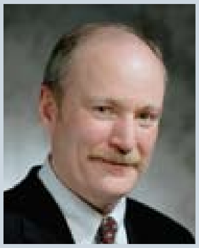
MISSION AREAS

- Space Control
- Air and Missile Defense Technology
- Communications and Information Technology
- Intelligence, Surveillance, and Reconnaissance Systems and Technology
- Advanced Electronics Technology
- Tactical Systems
- Homeland Protection
- Air Traffic Control

SPACE CONTROL

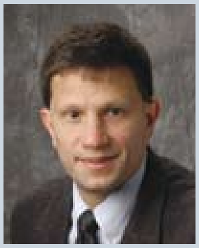
The Space Control mission develops technology that enables the nation's space surveillance system to meet the challenges of space situational awareness. Lincoln Laboratory works with systems to detect, track, and identify man-made satellites; performs satellite mission and payload assessment; and investigates technology to improve monitoring of the space environment, including space weather and atmospheric and ionospheric effects. The technology emphasis is the application of new components and algorithms to enable sensors with greatly enhanced capabilities and to support the development of net-centric processing systems for the nation's Space Surveillance Network.

Leadership

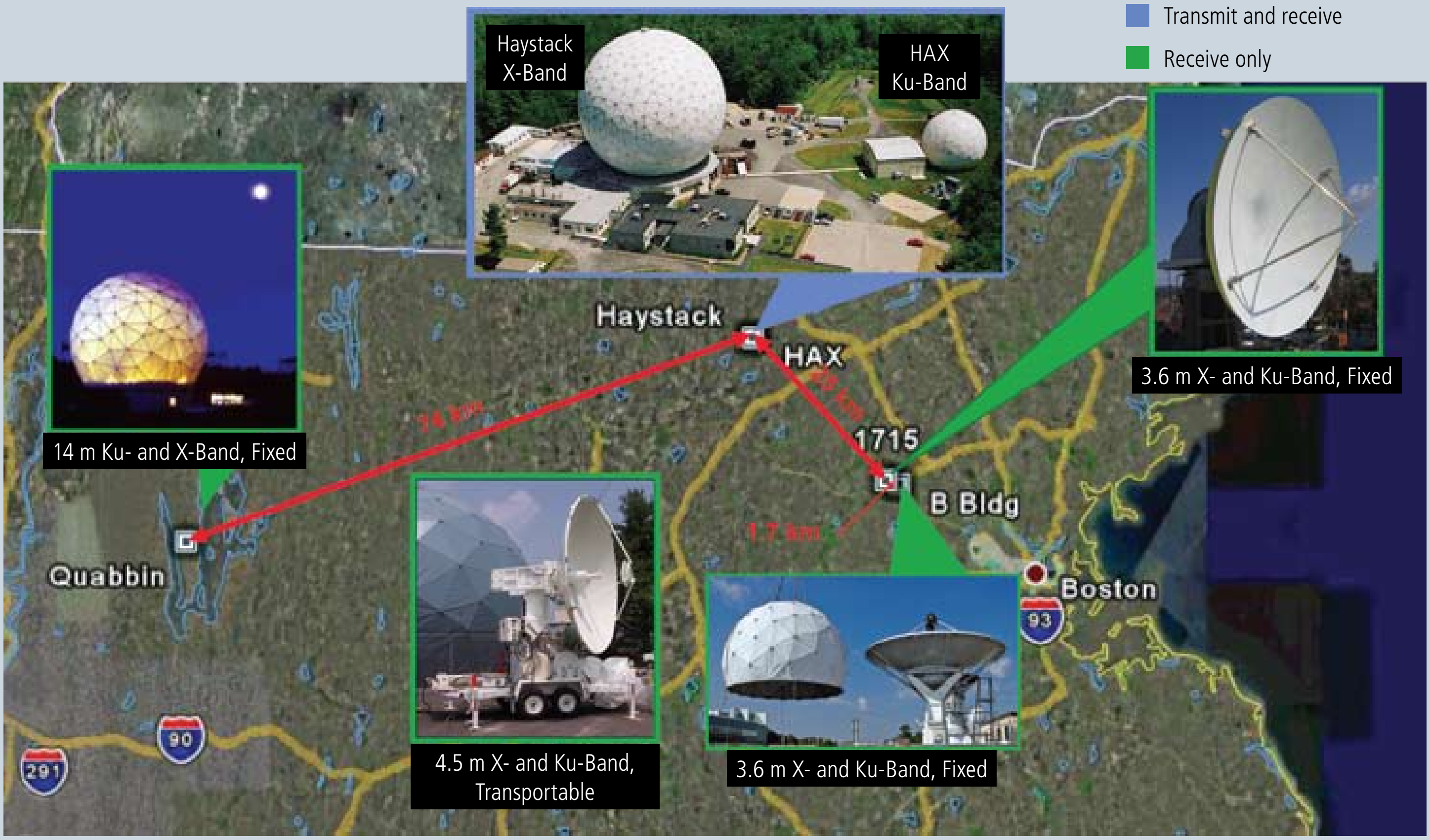


Dr. Grant H. Stokes

Dr. Hsiao-hua K. Burke



Mr. Lawrence M. Candell

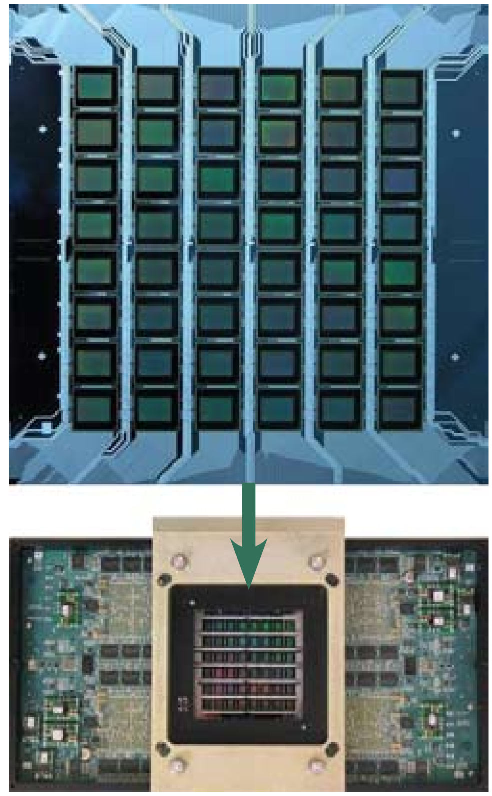


A sparse aperture radar test bed has been established to conduct research on bistatic radar for space surveillance applications. Illumination is provided by the Haystack and HAX radars, and receive antennas are distributed across Massachusetts.

Principal 2008 Accomplishments

- The Extended Space Sensors Architecture (ESSA), a net-centric test bed for space situational awareness, is now providing real-time radar imagery of satellites to military users on the SIPRNet. ESSA is also incorporating Net-Centric Enterprise Services software, developed by the Defense Information Systems Agency, to facilitate use of ESSA across multiple sensors and military organizations.
- Development of the Space Surveillance Telescope (SST) is proceeding through optical processing, with the tertiary mirror complete and polishing commencing on the larger primary mirror. Assembly of the azimuth base and yoke has been completed, and motor testing is under way. Groundbreaking for the telescope enclosure at Atom Site on the White Sands Missile Range occurred in January 2008.
- The Lexington Space Situational Awareness Center (LSSAC) successfully supported the launch of the Wideband Global SATCOM Flight 1 satellite and DSP Flight 23 this past year. LSSAC also supported the tracking and characterization of 59 newly launched satellites.
- Optical Processing Architecture at Lincoln (OPAL) has continued its development toward a common processing architecture for a broad range of sensors. OPAL provides mission planning and data processing for space surveillance sensors. Deliveries of the OPAL system were completed to a number of sensor installations, and new sensors were identified that will utilize the OPAL software in the future.
- The Haystack Ultrawideband Satellite Imaging Radar high-power transmitter demonstrated paired-tube power combining and diplexing. Fabrication of all surface panels for the upgraded Haystack antenna has been completed. Alignment of the panels to achieve required surface tolerance has also been demonstrated.
- Advanced technologies and processing techniques for future National Oceanic and Atmospheric Administration missions continue to be developed and demonstrated. The Laboratory is incorporating an infrared digital focal-plane array into a Fourier transform interferometer system, demonstrating 1.5× improved performance with 100× improved speed in atmospheric sounding products and establishing a path from phenomenology to product development through modeling.

The Space Surveillance Telescope will provide advanced ground-based optical system capability to enable detection and tracking of space objects.



The Laboratory successfully deployed exploitation systems for wide-area persistent surveillance and an 880 megapixel video camera for surveillance applications. Above is the Multi-Aperture Sparse Imager Video System (MASIVS) focal plane with a single MASIVS camera.

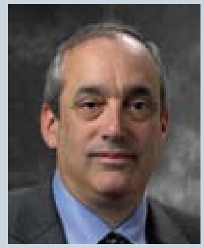
Future Outlook

- Emerging technical areas include advanced radar development, radar surveillance, space object identification, electro-optical deep-space surveillance, collaborative sensing, and identification fusion and processing.
- Lincoln Laboratory is pursuing several initiatives in the Space Control area that include the next generation of sensor systems and downstream processing/information-extraction systems, such as
  - A small-aperture, space-based, space surveillance system to provide wide-area search of the geosynchronous belt every 90 minutes for submeter-size objects
  - A passive, ground-based, wide-angle "fence" search system for detecting low Earth-orbiting satellites, utilizing unique curved charge-coupled-device focal planes to achieve the wide coverage
  - Net-centric machine-aided decision support algorithms to allow the operators in the Joint Space Operations Center to react to emerging threats to space assets
  - Incorporation of space environment monitoring as part of integrated space situational awareness
  - Initiation of efforts in climate-change modeling via novel sensor design in the far long-wave infrared

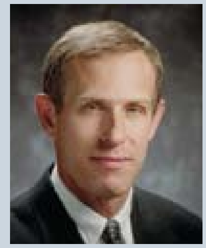
AIR AND MISSILE DEFENSE TECHNOLOGY

In the Air and Missile Defense Technology mission, Lincoln Laboratory works with government, industry, and other laboratories to develop integrated systems for defense against ballistic missiles, cruise missiles, and air vehicles in tactical, strategic, and homeland defense applications. Activities include the investigation of system architectures, development of advanced sensor and decision support technologies, development of flight-test hardware, extensive field measurements and data analysis, and the verification and assessment of deployed system capabilities. The program includes a focused evaluation of the survivability of U.S. air vehicles against air defense systems. A strong emphasis is placed on the rapid prototyping of sensor and system concepts and algorithms, and the transfer of the resulting technologies to government contractors responsible for the development of operational systems.

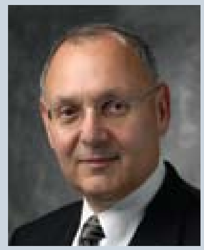
Leadership



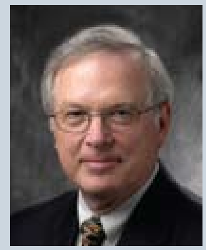
Dr. Marc D. Bernstein



Dr. Andrew D. Gerber



Mr. Gerald C. Augeri



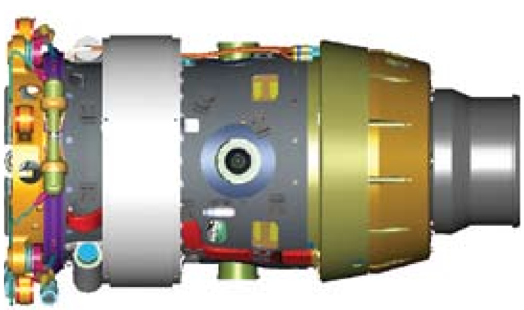
Mr. Dennis J. Keane

The Lincoln Laboratory–developed pixel processing imager will enable significantly improved infrared sensor performance across a wide range of ballistic missile defense, air defense, and persistent surveillance applications.

A 16-channel digital array radar test bed is being used to develop the signal processing algorithms and architecture for the Navy's new S-band air and missile defense radar for the CG(X) cruiser.

Principal 2008 Accomplishments

- A pixel processing imager (PPI) developed at Lincoln Laboratory will enable greatly improved infrared sensor performance across a wide range of ballistic missile defense, air defense, and persistent surveillance applications. The PPI device is formed by mating a detector array to a Lincoln Laboratory–developed digital readout integrated circuit. The PPI has significantly improved dynamic range, area coverage rate, and on-chip image processing power, compared to analog or conventional digital readout technologies. PPI devices will allow the development of large, high-resolution, high-frame-rate imagers and will also allow modestly sized imagers to scan quickly over wide fields of regard.
- The development of a mobile X-band instrumentation radar (XTR-1) proceeded into the system integration and checkout phase at the Lincoln Space Surveillance Complex in Westford, Massachusetts. The XTR-1 will become the radar component of the Missile Defense Agency's (MDA's) mobile range concept. The radar is based on the modern Radar Open Systems Architecture originally developed for the suite of instrumentation radars at the Reagan Test Site. The XTR-1 will begin participating in Ballistic Missile Defense System (BMDS) flight testing in 2009.
- Lincoln Laboratory in cooperation with the Australian Defence Science and Technology Organisation completed the first demonstration of critical components of a next-generation over-the-horizon (OTH) surveillance radar using modifications to the Australian operational Jindalee OTH Radar Network. New radar waveforms and adaptive processing techniques were developed and utilized to significantly reduce the effects of multiple propagation paths on target detection. The technology is being integrated by the Laboratory into a radar test bed for the next-generation U.S. OTH radar.
- The Reagan Test Site (RTS) Distributed Operations project successfully completed several engineering and test milestones, including a Critical Design Review. The development and integration of this modern net-centric control, communication, and sensing architecture for the RTS allow missile test and space operations occurring at RTS to be conducted from the U.S. Army Space and Missile Defense Command in Huntsville, Alabama.
- The Laboratory continues to have a significant role in the development of a new radar system for the Navy's E-2D Advanced Hawkeye airborne early-warning system. Lincoln Laboratory collected and analyzed data from the E-2D test bed flight-test program and provided an independent assessment of the performance of the new radar system. An additional flight-test campaign was conducted using Lincoln Laboratory's airborne test bed to examine the performance of advanced waveforms and algorithms for the E-2D upgrade.



Advanced discrimination algorithms for the new two-color seeker in the Standard Missile-3 vehicle have been transferred to the contractor.

A transportable X-band radar (XTR-1) will be integrated on a ship to support missile defense testing in the Pacific Ocean.

Future Outlook

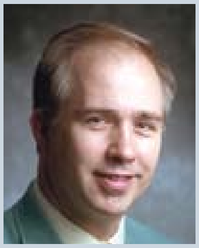
- Lincoln Laboratory will have a large role in characterizing the capabilities and limitations of the recent initial operational deployment of the BMDS and in helping to develop, refine, and verify tactics, techniques, and procedures to optimize performance. The Laboratory will also be actively engaged in the analysis, development, testing, and implementation of capabilities for the BMDS beyond initial deployment. Areas of particular focus will be system-wide tracking and discrimination, system-level testing, and advanced counter-countermeasures techniques.
- The Laboratory will be working with MDA, NORTHCOM/NORAD, and STRATCOM to define architectures for the defense of the U.S. homeland against asymmetric attacks by cruise missiles or short-range ballistic missiles launched from ships off the U.S. coast. An initial prototyping effort is being examined in the National Capital Region as an extension of the Enhanced Regional Situation Awareness system currently in place to provide a defensive capability against such threats.
- The Laboratory will support the development and integration of advanced technologies into the Surface Navy, with emphasis on a new S-band radar and electronic countermeasures for ship self-defense. Several key technologies, including wideband digital beamforming, are being developed for the next-generation S-band solid-state radar for the CG(X) cruiser. The Laboratory will also begin working on enhancements to an active decoy system to defend ships against future missile threats.

COMMUNICATIONS AND INFORMATION TECHNOLOGY

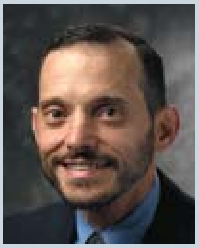
In the Communications and Information Technology mission, the Laboratory works to enhance the capabilities of current and future U.S. global defense communications networks (space, air, land, and sea) in the transport and knowledge domains. Emphasis is placed on developing architectures; identifying, prototyping, and demonstrating components, subsystems, and systems; and then transferring this technology to industry for use in operational systems. Current efforts span all network layers (from physical to application), with primary focuses on satellite communications, aircraft and vehicle radios and antennas, tactical networking, language processing, and computer network operations.

Leadership


Dr. J. Scott Stadler


Dr. Roy S. Bondurant


Mr. Stephan B. Rejto


Dr. Marc A. Zissman

The Lincoln Laboratory–developed Ka-band test terminal was used at Camp Parks, California, to perform early characterization of the first Wideband Global SATCOM system payload.

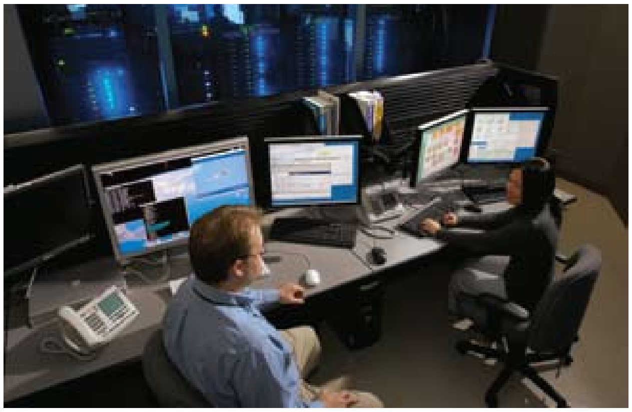
Principal 2008 Accomplishments

- Lincoln Laboratory collaborated with industry to validate design standards for the critical technologies needed for Transformational Communications: RF signaling waveforms and formats, network protocols, and lasercom (pointing, acquisition and tracking, and optical waveforms). Under government supervision, validation of contractor hardware was performed on a Lincoln Laboratory–constructed test and evaluation infrastructure.
- Early on-orbit checkout of the Wideband Global SATCOM (WGS) payload was performed using a Lincoln Laboratory–developed Ka-band "over-the-air" test capability at Camp Parks, California. The test terminal implemented key components of a new Ka-band waveform for the Air Force's Family of Advanced Beyond-line-of-sight Terminals. This waveform will be used for wideband readout of airborne intelligence, surveillance, and reconnaissance sensors on unmanned aerial vehicle platforms.
- The Laboratory developed an "over-the-air" interim payload command-and-control (IC2) capability that will also be used for testing and calibrating the Advanced EHF (AEHF) payload. The IC2 capability was deployed to Lincoln Laboratory, Schriever AFB, and Vandenberg AFB.
- The Paul Revere airborne laboratory participated in flight-test campaigns to assess the effectiveness of future air node ISR transport, communications backbone, and network middleware concepts.
- A net-centric software toolkit was developed to enable the rapid deployment of multisensor applications. This toolkit was demonstrated in a cross-mission scenario, showing how space situational awareness and missile defense assets could be employed cooperatively.
- Lincoln Laboratory participated in the most recent government-sponsored international evaluation of language-identification systems. The Laboratory's systems exhibited best-of-breed performance across most evaluation conditions.
- The Laboratory developed the first system that performs both joint static and dynamic analysis of source code to find vulnerabilities in software. Quantitative evaluation of the system demonstrated that this hybrid system yields better vulnerability detection than either static or dynamic analysis alone.
- The Lincoln Adaptable Real-time Information Assurance Testbed (LARIAT) was deployed at the Information Operations Range for the Joint Forces Command (JFCOM). JFCOM used LARIAT for war-fighter training and experimentation in which LARIAT controlled experiments and provided background traffic for thousands of host computers.
- Lincoln Laboratory developed a government reference implementation of a next-generation airborne networking waveform for the Joint Tactical Radio System (JTRS) and built and delivered a simulation and test environment for the JTRS enterprise networking services gateway.
- Optical free-space communication at high data rates (multiple gigabits/second) was demonstrated at efficiencies of better than 1 bit per photon.

This mechanical prototype of a next-generation, low size, weight, and power lasercom terminal is being developed for NASA science and exploration missions.

Future Outlook

- Lincoln Laboratory will use the interim payload command-and-control capability to support the initial operation of the AEHF satellite.
- Research in Counterterror Social Network Analysis and Intent Recognition will continue. A prototype system will be developed that will help intelligence analysts process multimedia data to identify the capabilities and intent of terrorist networks.
- A field measurement campaign will be conducted as part of the Empire Challenge ISR exercise on behalf of the Airborne Warning and Control System (AWACS) Program Office. It will serve as a test and evaluation event of the near-term network-centric capability of the AWACS fleet.
- Transformational Communications Satellite test beds and government-reference systems will be enhanced to permit testing of evolving contractor systems.
- Development and deployment of computer network attack and analysis tools will be undertaken to evaluate the robustness of the Army's Future Combat System and other future DoD systems.
- The Laboratory will design and develop a ground node capable of on-the-move communication with the AEHF satellite system.

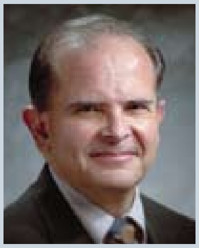


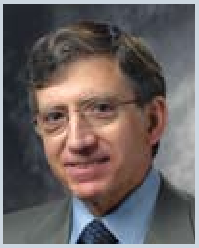
The Lincoln Adaptable Real-time Information Assurance Testbed (LARIAT) has been deployed to dozens of government and contractor facilities. LARIAT provides a high-fidelity emulation of networks with 1000s of hosts and 10,000s of users, allowing evaluation of information operations tools and techniques.

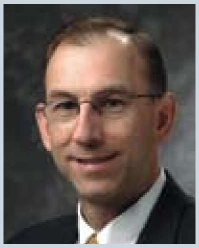
INTELLIGENCE, SURVEILLANCE, & RECONNAISSANCE SYSTEMS AND TECHNOLOGY

The Intelligence, Surveillance, and Reconnaissance (ISR) Systems and Technology mission conducts research and development in advanced sensing concepts, tracking and exploitation techniques, networked sensor architectures, and decision systems. Work encompasses airborne and spaceborne radar, high-resolution laser radar, passive geolocation systems, and undersea acoustic surveillance. ISR systems work relies upon the Laboratory's expertise in the enabling technologies of high performance embedded computing, advanced RF and laser sensing, adaptive signal processing, and pattern recognition techniques.

Leadership


Mr. David R. Martinez


Dr. Curtis W. Davis III


Dr. James Ward

Lincoln Laboratory researchers are developing 3-D laser detection and ranging imaging prototypes for simultaneous imagery and wide-area mapping of urban areas.

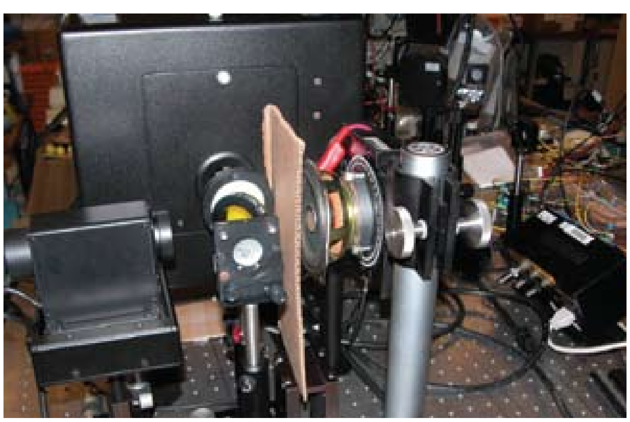
Principal 2008 Accomplishments

- Lincoln Laboratory conducted a large-scale surface surveillance experiment with multiple airborne sensors, including electro-optic imagers and moving target indication radars. The objectives were to assess the feasibility of detecting and tracking difficult targets moving between open rural areas and cluttered urban environments, and to develop the required processing techniques and multiple-sensor data-fusion and handover concepts.
- The Laboratory has developed techniques for detecting dismounted personnel and is researching the feasibility of discriminating between personnel and other target types. A field exercise to collect dismount radar phenomenology was planned and conducted.
- Lincoln Laboratory's active experimental campaigns included several collections performed to demonstrate architectural concepts using an active electronically scanned array together with a battle management, command-and-control suite. The experiments were undertaken to demonstrate the ability of commanders to respond to the agile behavior of enemy targets in an emulated global-war-on-terror scenario. These efforts led to the insertion of fusion and exploitation tools into an experimental suite of capabilities used by the National Geospatial-Intelligence Agency.
- In the advancement of ISR net-centric architectures, Lincoln Laboratory is evaluating and demonstrating the ability to search and discover information across multiple ISR federated systems. In addition, for the Distributed Common Ground System–Navy, the Laboratory has completed an enterprise architecture assessment that will help in framing the architecture for the objective system.
- Lincoln Laboratory has developed new passive sonar beamforming algorithms for submarine bow sphere arrays. New computationally efficient approaches for conventional beamforming were developed and shown to outperform legacy systems. This modernization has enabled the application of adaptive beamforming for additional benefit in dense contact environments. The new approaches have demonstrated significant benefits with recorded Fleet data, and the Laboratory is working closely with the Navy and industry on algorithm technology transition.
- The Laboratory completed a prototype microprocessor chip showing the ability to cancel nonlinearities commonly found in complex receiver systems. This capability will permit lower-performing analog-to-digital converters to be used without sacrificing performance.
- In support of transitioning technology, sharing results with the community, and reaching national consensus, Lincoln Laboratory hosts several annual workshops that have had significant impacts on their respective communities: High Performance Embedded Computing, Integrated Sensing and Decision Support, Adaptive Sensor Array Processing, and Surface Surveillance Technology.

Lincoln Laboratory has developed a mobile electronics intelligence (ELINT) receiver test bed to detect and analyze RF signals in real time.

Future Outlook

- Lincoln Laboratory is developing imaging sensors, automated processing algorithms, and processor technologies to improve the capabilities of persistent electro-optical systems for the Army and other agencies.
- Overland and maritime ISR exploitation techniques are being developed for next-generation airborne and space-based radars.
- Miniaturized digital receivers and sensor payloads are in development for small unmanned aerial vehicles, high-performance wideband passive geolocation, and high-resolution surface surveillance radar.
- The Laboratory will demonstrate the use of THz imaging for identification of explosive residues present on a person's clothing and hair.
- Ongoing efforts include development of a net-centric architecture for space and airborne ISR assets, and a multi-INT demonstration to assess the benefits of a service-oriented architecture approach.
- The first annual Intelligence, Surveillance, and Reconnaissance Systems and Technology Workshop will provide a forum for Laboratory researchers and key members of the national ISR community to engage with representatives from academia, industry, and government. The workshop will promote the dissemination of technical information, which is a principal activity within the Laboratory's mission.

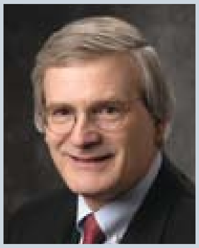


Ultra-high-resolution and terahertz imaging techniques are in development to improve the resolution of novel sensor systems.

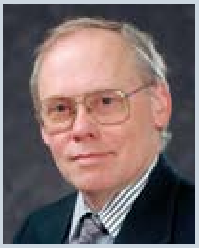
A high-performance embedded receiver and processor were developed to detect weak signals for a tactical platform.

ADVANCED ELECTRONICS TECHNOLOGY

Leadership



Dr. David C. Shaver

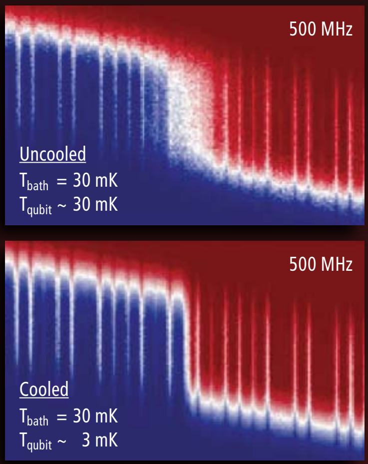


Dr. Richard W. Ralston

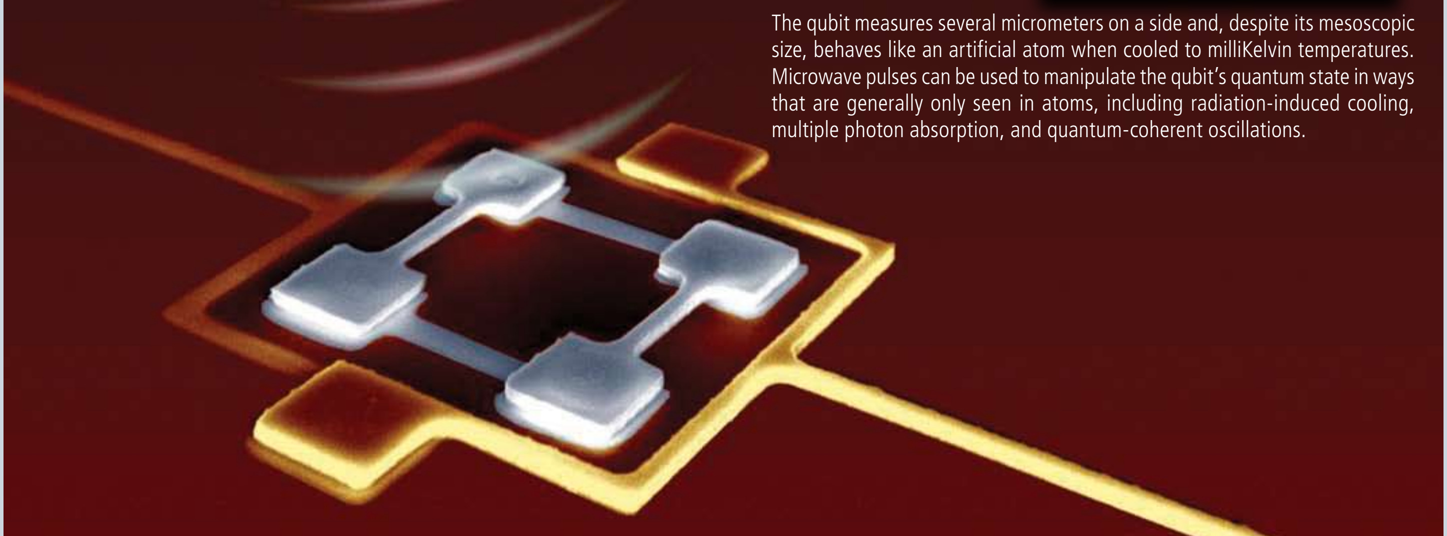
Dr. Charles A. Primmerman

Research and development in Advanced Electronics Technology (AET) focus on the invention of new device concepts, the practical realization of those devices, and their integration into subsystems. Although many of these devices continue to be based on solid-state electronic or electro-optical technologies, recent work is highly multidisciplinary, and current devices increasingly exploit biotechnology and innovative chemistry. The broad scope of AET work includes the development of unique high-performance detectors and focal planes, 3-D integrated circuits, biological and chemical agent sensors, diode lasers and photonic devices using compound semiconductors and silicon-based technologies, microelectromechanical devices, RF technology, and unique lasers including high-power fiber and cryogenic lasers.

Superconducting quantum bits, qubits, are being fabricated and manipulated with increasing complexity and precision as artificial atoms. The goal of these science experiments is to assess the feasibility of quantum computation via manipulation of a system of coupled qubits.



The qubit measures several micrometers on a side and, despite its mesoscopic size, behaves like an artificial atom when cooled to milliKelvin temperatures. Microwave pulses can be used to manipulate the qubit's quantum state in ways that are generally only seen in atoms, including radiation-induced cooling, multiple photon absorption, and quantum-coherent oscillations.



Color-enhanced scanning electron micrograph of a superconducting qubit

Principal 2008 Accomplishments

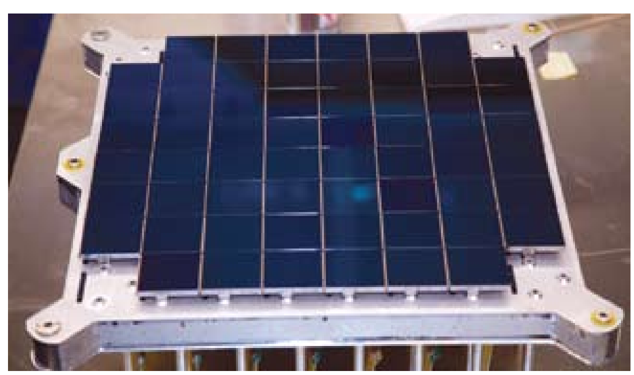
- A unique device called the orthogonal transfer array was developed for the Air Force's Panoramic Survey Telescope and Rapid Response System (PanSTARRS), which is a fast sky-survey system comprising four telescopes, each with a 1.4 gigapixel focal plane array (FPA). The first 1.4 gigapixel FPA was integrated into a recently constructed wide-field-of-view 1.8 m aperture telescope, and the first astronomical images were acquired.
- A 128 × 128-pixel, 50-sample charge-coupled-device imager and supporting electronics were provided to Lawrence Livermore National Laboratory (LLNL) for field tests. Measurements done at LLNL demonstrated that the imager operates at more than two million frames per second and is capable of exposure times as short as 200 ns.
- The superwideband compressive receiver program completed a second measurement campaign in a signals intelligence platform. The highlight of this test was the demonstration of full real-time processing of threat signals across a multi-GHz instantaneous bandwidth. The compressive receiver met or exceeded aggressive performance targets for sensitivity, dynamic range, and frequency accuracy.
- The Laboratory's unique 3-D integrated circuit technology was used to demonstrate functional 4-side-abuttable imaging modules for large "mosaic" focal plane arrays. In this architecture, the electronics for each pixel reside in tiers behind the high-fill-factor photodetection tier, enabling many key improvements, such as integration of multiple material and process technologies for optimized functionality.
- The slab-coupled optical waveguide laser (SCOWL) invented at Lincoln Laboratory is being utilized in novel, coherent-beam-combining architectures with individually addressable array elements. Record combined power levels were achieved. The SCOWL structure produced semiconductor optical amplifiers that have power higher than previously reported and that enable narrow line widths with low noise in a compact package. Mode-locked SCOWL devices have demonstrated record output powers in short-pulse operation.
- Cryogenic Yb:YAG laser technology has been demonstrated in a laboratory prototype as a high-power illuminator. Operation with liquid-nitrogen cooling (–320°F) improved lasing efficiency and reduced thermo-optic distortions, thereby resulting in more than double the pulse energy in a higher-quality laser beam compared to a room-temperature device. Engineering of an illuminator for field system tests has been completed.
- The Laboratory's low-loss (<0.15 dB), broadband (3–110 GHz), fully packaged radio frequency microelectromechanical switch (RF MEMS) technology surpassed 300-billion-cycle reliability testing and is in its final stages of technology transfer to a domestic foundry that will make this state-of-the-art, high-reliability technology available to the entire DoD contractor community.

Technical staff member inspects high-performance imagers under a microscope.

The Microelectronics Laboratory is a 70,000-square-foot semiconductor research and fabrication facility used to develop advanced microelectronics devices in state-of-the-art clean rooms with semiconductor processing tools.

Future Outlook

- Additional applications will continue to drive the development of focal plane arrays with higher pixel counts, smaller pixels, and more highly integrated "camera" electronics. Focal plane array designs will exploit integrated circuit fabrication, chip tiling, and 3-D packaging technologies for a wide variety of charge-coupled and photodiode sensors. Near-term applications will include passive imaging and active ladar for surveillance. Longer-term applications will include optical communication.
- Efficient, high-energy electrical laser sources are a long-term objective. Techniques for combining the beams of arrays of diode lasers will be scaled from tens to hundreds of devices. The slab-coupled optical waveguide device structure has key advantages for such combined sources.
- Conventional silicon transistor technology is reaching the end of the micro-miniaturization trend (recognized as Moore's Law). Researchers in Advanced Electronics Technology are seeking to push performance beyond that of scaled silicon. Efforts include graphene (thin-film carbon) transistors and exploration of the combination of bio- and nano-technologies for self-assembled electronics.



A unique orthogonal transfer array has been developed for synoptic space surveys in the Air Force's Panoramic Survey Telescope and Rapid Response System (PanSTARRS). The 60-chip array is 40 cm × 40 cm.

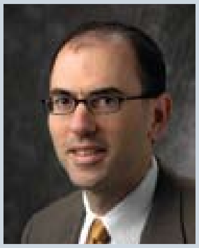
TACTICAL SYSTEMS

In the Tactical Systems mission, Lincoln Laboratory focuses on assisting the Department of Defense to improve the acquisition and employment of various tactical air and counterterrorist systems. The Laboratory does this by helping the U.S. military understand the operational utility and limitations of advanced technologies. Activities focus on a combination of systems analysis to assess technology impact in operationally relevant scenarios, rapid development and instrumentation of prototype U.S. and threat systems, and detailed, realistic, instrumented testing. The Tactical Systems area is characterized by a very tight coupling between the Laboratory's efforts and the DoD sponsors and warfighters involved in these efforts. This tight coupling ensures that the analysis that is done and the systems that are developed are relevant and beneficial to the warfighter.

Leadership

Dr. Robert T-I. Shin

Dr. Robert G. Atkins



Dr. Eliahu H. Niewood

The Airborne Seeker Test Bed is used to provide instrumented testing of operational sensors and detailed phenomenology measurements.

Principal 2008 Accomplishments

- Lincoln Laboratory conducted a comprehensive assessment of options for U.S. Air Force airborne electronic attack against foreign surveillance radars. This assessment included systems analysis of various proposed options, development of detailed models of threat surveillance radars and their electronic protection systems, and testing of various electronic attack systems and surveillance radars. A major focus was development of a system for implementing advanced electronic protection on an older surveillance radar. This system is currently undergoing initial testing.
- The Laboratory conducted initial flight testing of a new pod on the Airborne Seeker Test Bed with three infrared missile seekers. These seekers were tested against a variety of targets, including business jets, helicopters, and fighter aircraft with and without countermeasures.
- A number of assessments were performed examining the impact of exporting advanced military systems. These assessments were used by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics and by Congress as part of the decision-making process for a number of major export programs.
- The Laboratory completed development of an advanced signals intelligence receiver designed for counterterrorism applications. The multichannel receiver is unique to this application in its use of adaptive beamforming to suppress interference sources and to preserve receiver sensitivity. The receiver system, along with a custom-built antenna array, was flight tested. The Laboratory is now working with the user community to transition this technology to theater as a quick-reaction capability.
- Countermeasures to several counterinsurgency threat devices were assessed and tested. Threat devices were measured and analyzed to understand their behavior and to determine exploitable characteristics. A number of exploitation approaches were laboratory tested, and the results of these tests were used to assess the viability of concepts of operations employing these approaches.
- Lincoln Laboratory is supporting a number of air traffic control–related efforts for the U.S. Air Force. As part of these efforts, the Laboratory is developing a prototype collision-avoidance system for the Global Hawk unmanned aerial vehicle (UAV). This system will be based on a dynamic simulation facility developed by Lincoln Laboratory to model system performance over a wide range of encounter situations.

The Laboratory is actively engaged in integrating advanced sensors on unmanned aerial vehicle systems, such as the AAI Shadow 200.

Lincoln Laboratory developed and successfully tested this multichannel signals intelligence receiver, which has enabled the Laboratory to rapidly innovate, develop, and test novel sensor capabilities for a variety of critical national problems. Key features include low noise figure, wide bandwidth, and direction-finding capability.

Future Outlook

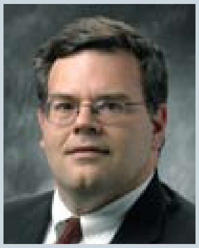
- The Laboratory will continue to play an important role in helping the U.S. Air Force develop advanced electronic attack and electronic protection systems. The Laboratory will continue to develop new systems to evaluate future air defense threats. One planned effort is to use an existing passive surveillance system as a baseline for examining the impact of potential advanced signal processing techniques on passive system performance.
- The Laboratory will also continue the development of an advanced electronic attack test bed aircraft. This aircraft will be used primarily to support testing of the electronic protection features of U.S. fighter aircraft radars. This test bed will also be used in the development of advanced electronic protection techniques for fighter radars and to support the development of electronic attack against surveillance radars.
- Lincoln Laboratory is planning continued enhancements of its rapid development capabilities to address needs in counterterrorism and other applications. The Laboratory's broad technical expertise and its agility in assessing and prototyping novel and complex systems strongly position the Laboratory to rapidly respond to threats in the continuing Global War on Terrorism. The greater use of software-defined systems, activities to better understand and exploit consumer electronics, and dedicated rapid innovation facilities are being planned to further enhance the Laboratory's ability to rapidly develop.
- The Laboratory's Blue Team efforts are expected to become more involved in the development of new sensing capabilities specific to counterterrorism applications. Expected trends include novel tracking approaches; an importance to supporting small units with advanced sensors, such as advanced sensors integrated in small UAV platforms; and a need for high-precision geolocation in all sensor modalities.

HOMELAND PROTECTION

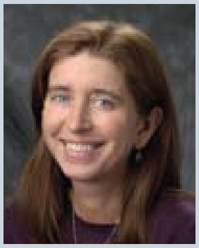
The Homeland Protection mission is supporting the nation's homeland security by developing technology and systems to help prevent terrorist attacks within the U.S., to reduce the vulnerability of the U.S. to terrorism, and to minimize the damage and assist in the recovery from terrorist attacks. Current sponsors for this mission area include the Department of Homeland Security, Department of Defense, and other federal, state, and local entities. Efforts include architecture studies for the defense of civilians and facilities against potential biological attacks, development of the Enhanced Regional Situation Awareness system for the air defense of the National Capital Region, development of cyber-security technology for critical homeland infrastructure protection, and development of collision-avoidance technology to enable the use of unmanned aerial vehicles.

Leadership

Dr. Robert T-I. Shin



Dr. Israel Soibelman



Dr. Bernadette Johnson

The theater Enhanced Target Range and Classification (ETRAC) Sentinel Radar is being utilized to collect data in support of Homeland Air Defense efforts.

The radar shown here on a tower at the Laboratory's Katahdin Hill site captures a view of the Boston airspace.

Principal 2008 Accomplishments

- Lincoln Laboratory continued the refinement and technology transition of the Enhanced Regional Situation Awareness (ERSA) system in support of Homeland Air Defense around the National Capital Region.
- Significant sensor improvements to ERSA include installing the theater Enhanced Target Range and Classification Sentinel Radar on Katahdin Hill at Lincoln Laboratory and collecting data. A technical interchange with the Aviation and Missile Research, Development, and Engineering Center Program Office was held to review results and strategies for modifying this theater system to meet the needs for Homeland Defense.
- A biological and chemical facility protection test bed was demonstrated that allows for the development and testing of detection technologies and response strategies in a realistic setting.
- The Laboratory demonstrated prototype rapid biological trigger devices, including a high-performance sensor employing multiple measurement modalities that was shown to be best-in-breed in field tests and a low-cost alternative that uses ultraviolet light-emitting diodes.
- In support of the Department of Homeland Security (DHS), the Laboratory initiated measurements and analysis of the feasibility of rapid detection of biological and chemical threats in shipping containers.
- Lincoln Laboratory led a consortium effort to design tools that simplify the process of securing critical infrastructures.
- Lincoln Laboratory supported the need of the DHS for safe, on-demand operation of unmanned aircraft through the development of modeling and simulation tools that will be critical for system certification.
- The Laboratory developed speaker-comparison software tools; demonstrated their state-of-the-art performance in independent evaluations; and transitioned them to the DHS, where they are used in forensic voice-examination casework.

The Rapid Agent Aerosol Detection program is developing technology for high-performance, lightweight, integrated chemical and biological aerosol detection. Field trials have shown reduced false-positive rates and higher agent sensitivity over prior-generation detectors.

The Enhanced Regional Situation Awareness system is being integrated with other key technologies to form the nation's advanced architecture for Homeland Air Defense. Other key technologies include passive sensors, over-the-horizon radar, and radio frequency threat identification.

Future Outlook

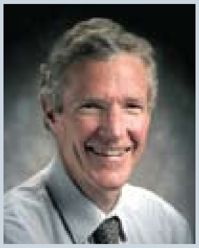
- The Laboratory will assist NORAD-NORTHCOM in actively pursuing strategies to expand their capability to defend North America against an expanding variety of potential threats.
- A net-centric ERSA will be developed to form the backbone for a regional Homeland Air Defense capability.
- The Laboratory foresees studies relating to architecture development for urban biodefense as well as test and evaluation of bio-chem systems for defense of facilities, including buildings of military and civilian significance.
- Further development and transition of rapid biological trigger technology to the DoD and DHS are expected.
- The Laboratory will perform an investigation into the biological and chemical defense needs and requirements of DHS organizations such as the Transportation Security Administration, Federal Emergency Management Administration, Customs and Border Patrol, and the Office of Health Affairs.
- Further development and testing of a universal and rapid biological sample preparation are planned.
- The Laboratory will apply its analytical expertise to provide an independent safety assessment of sense-and-avoid system concepts for Predator and other unmanned aircraft to support Customs and Border Protection missions.

A Department of Homeland Security project is assessing potential methods for rapid screening of shipping containers for chemical and biological threat without negatively impacting throughput.

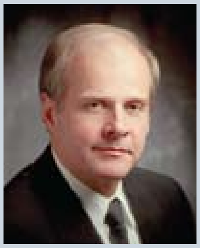
AIR TRAFFIC CONTROL

Since 1971, Lincoln Laboratory has supported the Federal Aviation Administration (FAA) in the development of new technology for air traffic control. This work initially focused on aircraft surveillance and weather sensing, collision avoidance, and air-ground communications. While the Laboratory continues to support the FAA in these areas, the current program focuses on the development of safety- or capacity-enhancing systems that exploit this surveillance, weather, and communications infrastructure. Key activities include the operation of a national-scale integrated weather-sensing and decision-support prototype; testing and technology transfer of a runway-incursion prevention system; and the development of a net-centric, system-wide information management system.

Leadership

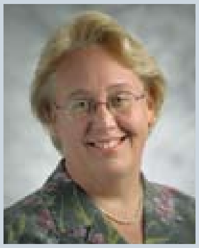


Dr. Mark E. Weber



Mr. James M. Flavin

Ms. Elizabeth R. Ducot



Dr. Marilyn M. Wolfson

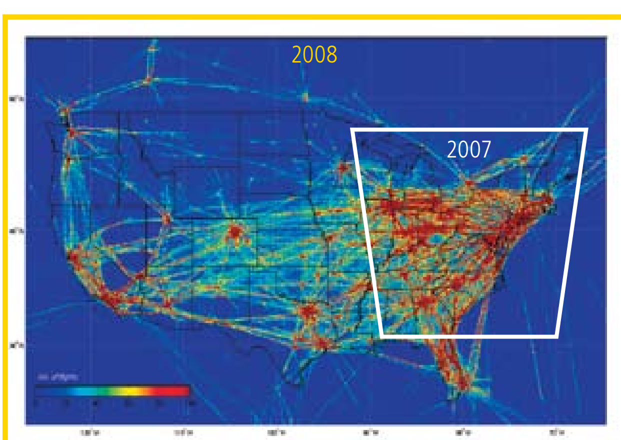
Dr. James K. Kuchar

Dr. Herbert E.M. Viggh

In Lincoln Laboratory's Air Traffic Management Laboratory, the display on the right is from the Runway Status Lights system prototype operating at Dallas/Fort Worth Airport to prevent inadvertent incursions on the active runway. The display on the left shows aircraft movement throughout the U.S. airspace with weather overlaid.

Principal 2008 Accomplishments

- The Laboratory-developed Corridor Integrated Weather System (CIWS) is being reengineered to provide continental United States (CONUS-wide) coverage and a robust configuration suitable for handoff to the FAA for long-term operation. The initial phase for this national CIWS was deployed in June 2008.
- The Runway Status Lights system continues operation at Dallas/Fort Worth International Airport. The system was expanded to additional runways and is undergoing testing of a Final Approach Runway Occupancy Signal to prevent landing accidents. A shadow evaluation (without lights installed) was also performed at Chicago O'Hare International Airport to assess algorithms to prevent conflicts at runway intersections.
- The Laboratory is supporting the FAA's acquisition of a national Automatic Dependent Surveillance–Broadcast (ADS-B) system. The Laboratory analyzed surveillance requirements and radar/ADS-B fusion algorithms needed for air traffic control (ATC) at key ADS-B sites. This work included the analysis of wide-area multilateration (locating aircraft by computing time difference of arrival of multiple radio signals) as a backup for ADS-B.
- The Laboratory is working with the FAA to refine concepts for a next-generation Multifunction Phased Array Radar (MPAR) that would provide the surveillance services currently acquired from separate ATC and weather radar networks. Current activities include analysis of how MPAR might improve thunderstorm-forecasting capabilities, an assessment of its role as a backup for ADS-B, and demonstration of ultra-low-cost S-band array technology.
- Enhanced air traffic management tools were developed that exploit emerging weather-forecast capabilities to assist with the execution of reroute and delay programs. This work includes the operation of a Route Availability Planning Tool (RAPT). RAPT has been identified by the FAA as a component of the government's strategy to reduce flight delays affecting New York City airports during severe weather.
- The Laboratory completed the development of a national airspace encounter model under the joint support of the FAA, Department of Defense, and Department of Homeland Security. This model is being used to design and evaluate collision-avoidance systems for manned and unmanned aircraft, including the Global Hawk and Predator.
- Based on successes at Lincoln Laboratory, the FAA has begun fielding a national monitoring program to assess and improve the performance of the Traffic Alert and Collision Avoidance System (TCAS) across the United States.

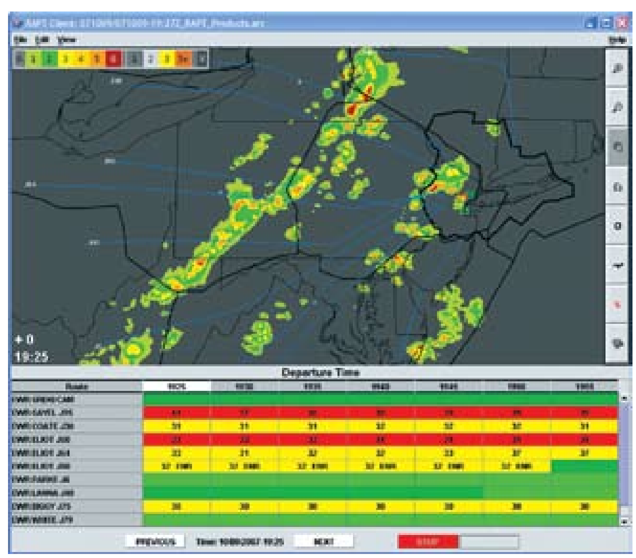


The CIWS domain is shown as a white outline overlaid on a map of the air traffic density on a clear-weather day. The ongoing CIWS reengineering effort permits coverage of the entire continental United States in 2008.

Lincoln Laboratory is supporting the FAA's development of ADS-B surveillance applications over the Gulf of Mexico. Satellite-derived positions for ADS-B will be merged with ground radar tracks to provide a high-quality integrated surveillance picture to air traffic controllers.

Future Outlook

- A modern FAA communications architecture will encompass sensor data, decision-support applications, and efficient sharing of information amongst the decision makers involved in operating the National Airspace System.
- Applications are planned that will leverage ADS-B to improve safety, efficiency, and capacity in congested airspace.
- Increased emphasis is being placed on the development and testing of next-generation paradigms for aircraft-separation assurance on the airport surface and during flight. This effort includes evolution of deployed collision-avoidance technologies such as TCAS and Runway Status Lights, as well as simulation, analysis, and robustness testing of future concepts.
- The Laboratory will develop concepts and prototypes of enhanced air traffic management decision-support tools focused on weather-delay reduction.
- Development and test of an MPAR prototype array with associated control and processing functions are under way to demonstrate aircraft and weather surveillance.
- The Laboratory will develop low-cost sensors and advanced algorithms to improve the safe integration of unmanned aircraft into civil airspace.



The Route Availability Planning Tool (RAPT) prototype is currently in operation in New York City airspace to test its effectiveness in reducing flight delays affecting New York City airports during severe weather.

WORKSHOPS AND SEMINARS

Lincoln Laboratory hosts annual conferences, workshops, and seminars that bring together members of technical and defense communities to share advancements and ideas. These events, a number of which are described below, foster a continuing dialogue that enhances technology development and provides direction for future research.

High Performance Embedded Computing (HPEC) Workshop – 18–20 September 2007

The HPEC Workshop provided U.S. government-funded researchers from academia, industry, and government an opportunity to discuss the impact of multicore processors on Department of Defense high performance embedded computing systems.

Surface Surveillance Technology (SST) Workshop – 23–24 October 2007

The SST Workshop brought together the users and developers of surface surveillance technologies to discuss needs and capabilities for countering obscured objects and difficult targets in the clear.

Project Hercules Program Review – 13–15 November 2007

The Project Hercules Program Review presented the current program in decision algorithm development to the Missile Defense Agency community.

Bio-Chem Defense Systems Workshop – 5–6 December 2007

The Bio-Chem Defense Systems Workshop presented the latest developments in technologies that address biological and chemical threats. Emphasis was on advanced sensing techniques.

Ballistic Missile Defense (BMD) Technology Course – 27–29 February 2008

The BMD Technology Course provided an understanding of BMD systems concepts and technologies to military officers and Department of Defense civilians involved in BMD systems development and acquisition.

Defense Technology Seminar (DTS) – 30 March–4 April 2008

DTS 2008 focused on technologies for the warfighter. Major sessions were devoted to missile defense and space situational awareness. New national security challenges in counterinsurgency warfare, homeland security, and network-centric operations were discussed.

This year marked the twelfth annual Defense Technology Seminar at Lincoln Laboratory. Attendees included military officers and Department of Defense civilians. The seminar focused on the application of advanced electronics technology to critical surface, air, and space military challenges. Eight distinguished guest speakers offered insights on current national security issues.

U.S. Air Force and MIT Lincoln Laboratory members of the U.S. Air Force Red Team are shown with Honorable Dr. William J. Perry, keynote speaker at the 30th Air Vehicle Survivability Workshop, MIT Lincoln Laboratory, 7–9 May 2008. The AVS Workshop covered issues related to performance of foreign air defense systems against U.S. aircraft, electronic countermeasures and counter-countermeasures, U.S. infrared system performance, lessons learned from operational experiences, potential future foreign threats and threat evolution, and counters to U.S. programs. Pictured from left to right: Dr. Eli Niewood (Lincoln Laboratory Program Manager), Lt Col (S) Joel Luker, Lt Col (S) David Dunn, Lt Col (S) Karl Schloer, Lt Col Charles Havasy, Lt Col David Hiltz (Red Team Chief), Hon. Dr. William Perry, Mr. Robert Wirt (Red Team Technical Director), Lt Col Stephen Russell, Dr. David Ebel, Dr. Aryeh Feder, Dr. Kevin Cohen, Mr. Jeffrey Gottschalk, and Mr. Mark Weiner.

Space Control Conference – 29–30 April and 1 May 2008

The Space Control Conference brought together the space control community to address current capabilities, future needs, and technology development.

Air Vehicle Survivability (AVS) Workshop – 7–9 May 2008

The AVS Workshop presented the air vehicle survivability community with an update on recent analysis and testing, and provided a forum for relevant briefings from the community. This year marked the 30th anniversary of the Air Vehicle Survivability program.

Ballistic Missile Defense (BMD) Joint Advisory Committee (JAC) Meeting – 13–15 May 2008

The BMD JAC Meeting provided the BMD community with an overview of current developments in areas such as missile defense elements, missile defense architectures, advanced concepts and technology, test infrastructures, and intelligence capabilities. At the meeting, Lincoln Laboratory celebrated 50 years of BMD work.

Communications and Networking Workshop – 18–19 June 2008

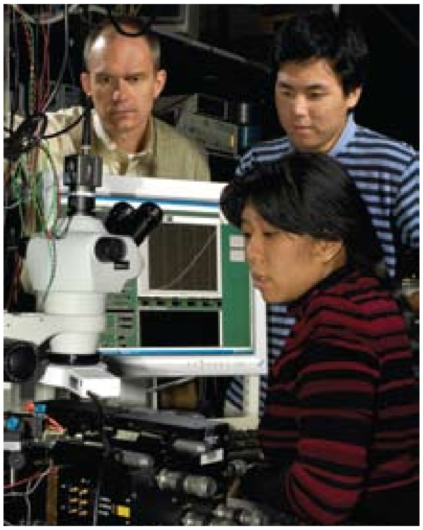
The Communications and Networking Workshop provided the user, acquisition, research, and developer communities with discussions on lessons learned, current trends, technical challenges, and the road ahead.

Introduction to Radar Systems 2008 – 24–26 June 2008

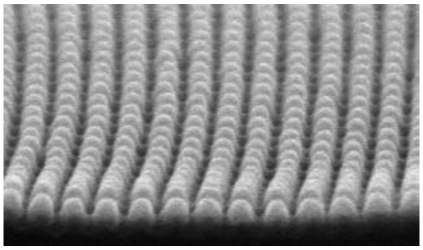
This course has been developed to provide an understanding of radar system concepts and technologies to military officers and DoD civilians involved in radar system development, acquisition, and related fields.

Advanced Electronics Technology (AET) Seminar – 9 September 2008

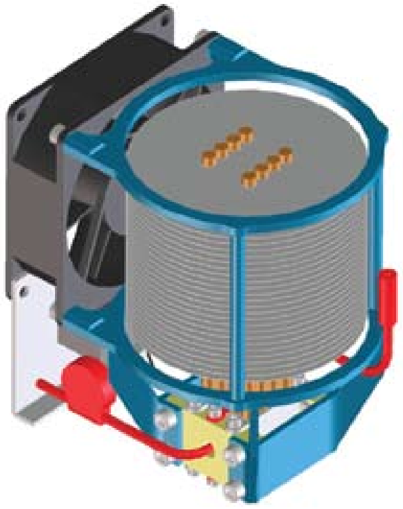
The AET Seminar provided an overview of the solid-state device and electronic subsystems efforts within the Solid State Division. In addition to the overview, selected topics were described in more detail within focus talks and poster presentations.



Paul Juodawlkis and MIT students Jade Wang and William Loh measure electrical and optical characteristics of semiconductor optical amplifiers contained in an all-optical switch. The switch was fabricated using a combination of campus and Laboratory resources.



An organic-based solar cell with a lithographically defined interface is an ACC initiative to demonstrate a 3-D device geometry that enables 2–3× efficiency improvements over planar geometry.



This is a system concept for an NTIP project to develop a portable 20 W thermoelectric generator that can be used to recharge batteries. This is a strong collaborative effort between multiple Laboratory divisions, MIT, and industry. The prototype will be built in early 2009.

MIT CAMPUS AND LINCOLN LABORATORY COLLABORATIONS

Integrated Photonics Initiative (IPI)

The IPI is a multiyear, Lincoln Laboratory–funded collaboration between the Laboratory and the MIT campus to support the research of doctoral candidates working on integrated photonic materials, devices, and subsystems. The objectives of the IPI are to identify Department of Defense mission areas that could benefit from integrated photonic technologies, develop these technologies through graduate research, and work to insert the technologies into advanced communication and sensor systems. Monthly IPI status meetings rotating between the Laboratory and the campus foster interaction between the students, Laboratory staff, and campus faculty. The Laboratory's specialized fabrication facilities and expertise in applied research provide beneficial dimensions to the students' thesis development.

During the past year, the IPI funded three on-campus students and two students working primarily at the Laboratory. The students focused on topics including fabrication and test of integrated ultrafast all-optical switches, development of hybrid optoelectronic integrated circuits, characterization of the noise and dynamic properties of high-power semiconductor optical amplifiers, investigation of materials for use in integrated optical isolators, and development of interferometric lithography techniques.

Advanced Concepts Committee (ACC)

The ACC supports the development of innovative concepts that address important technical problems of national interest.

The Lincoln Laboratory ACC provides seed funding, as well as technical and programmatic support, to investigators with new technology ideas. These ideas are typically high risk, but offer the potential to significantly impact national needs by enabling new systems or improving existing capabilities. Projects are scoped to demonstrate concept feasibility and typically last 9 to 12 months. The ACC encourages collaborative efforts between Lincoln Laboratory and MIT campus.

Recent ACC initiatives include technologies for imaging of geosynchronous satellites. The ACC is also currently supporting the development of biodefense technologies, such as an aerosol generator for use in standoff biodetection systems, as well as techniques for identifying individuals who have handled explosives.

The ACC sponsors a Defense Studies Seminar Series that includes speakers associated with the MIT Security Studies Program. The 2008 seminars included the following:

February 15, 2008	American Grand Strategy for the New Era **Professor Stephan Van Evera**, MIT Security Studies Program
April 25, 2008	A Nuclear Capable Iran: Containment or Preventive War **Professor Barry R. Posen**, Director, MIT Security Studies Program
May 16, 2008	Democratization and the Future of U.S.–China Relations **Assistant Professor Jennifer M. Lind**, Dartmouth College

New Technology Initiatives Program (NTIP)

The NTIP supports initiatives to significantly extend the application of new technologies and approaches to our nation's current and future problems.

The New Technology Initiatives Program works with the Laboratory community and outside resources to identify user needs, capability drivers, and enabling technologies. Board members provide leadership to frame a problem space, outline candidate architectures, identify emerging technical capabilities that might apply across the Laboratory, and approve funding for new initiatives. Interdivisional activities and risk-taking are encouraged.

Decision Modeling Research Initiative (DMRI)

The DMRI is a collaboration between technical staff members at Lincoln Laboratory and MIT's Stochastic Systems Group (SSG). The objective is to make significant contributions to the area of decision modeling.

With the deployment of complex sensor systems in diverse, challenging environments comes the need for autonomous decision-making and sensor-fusion algorithms. The DMRI is providing a forum for sharing research findings and ideas in order to develop enhanced and scalable sensor fusion, inference, and decision-making algorithms and methodologies. Joint discussions have promoted the transfer of SSG–developed algorithms to Laboratory researchers and in-depth dialogue on challenges of interest to Laboratory programs.

Through DMRI–sponsored seminars at Lincoln Laboratory, researchers have presented on a range of topics of relevance to decision modeling, including other technologies such as wide-angle SAR image formation and algorithms for large-scale inference.

DARPA URBAN CHALLENGE

MIT Lincoln Laboratory Radar Capability Prototyping for the DARPA Urban Challenge

The DARPA Urban Challenge was the third in a series of autonomous vehicle demonstrations. The first two involved completion of a 60-mile desert course with no external vehicle control. No vehicles completed the first event, but four succeeded in the second. Vehicles in the recent Urban Challenge were required to execute simulated military supply missions in a mock city environment. In this event, vehicles needed to sense and reason about environment, merge into moving traffic, navigate traffic circles, negotiate busy intersections, and avoid obstacles.

The MIT campus team (Team MIT), looking to develop technology beyond this one challenge, emphasized perception of the environment over reliance on GPS dead reckoning. Team MIT had a suite of optical sensors identified (pushbroom and scanning LIDARS and optical cameras) that operated effectively out to a few 10s of meters but lacked a "long-range" capability that appeared to be required from the Urban Challenge scenario descriptions. In November 2006, Team MIT presented their plans at Lincoln Laboratory, where suggestions for collaborations were solicited. In December 2006, a Lincoln Laboratory team (Robert Galejs, Jonathan Williams, and Siddhartha Krishnamurthy) was formed (using New Technology Initiatives Program funding) to help develop a long-range radar sensing capability for Team MIT's Urban Challenge entry.

Since the final Urban Challenge event was to be held in November 2007, only existing automotive radars were considered. The Lincoln Laboratory team chose the Delphi automatic cruise control (ACC) radar for this application. The ACC radar was then characterized in the laboratory as well as outdoors for detection and tracking accuracy, sensitivity to multi-radar interference, and clutter rejection. Results of these investigations were shared with Team MIT, who placed 15 of these ACC radars on their vehicle, along with 13 LIDARS, 6 cameras, and a GPS.

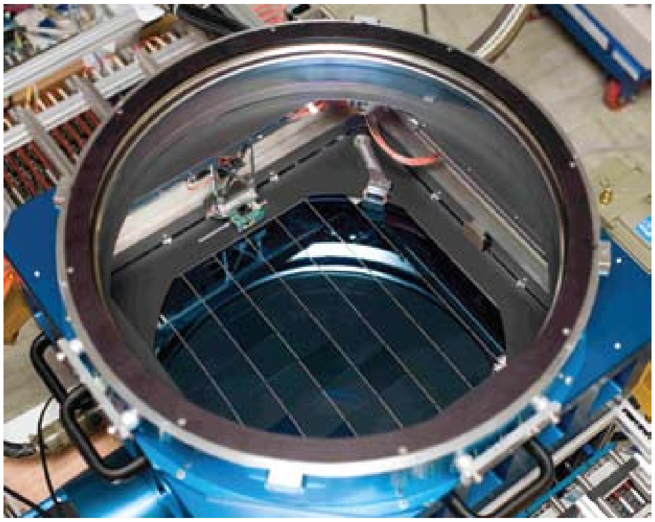
From the 89 initial entries, there were 35 semifinalists and 11 finalists, with the field being narrowed down through a series of increasingly difficult site visits and evaluations. Six vehicles successfully completed the final event in which all of the finalists had to complete a series of "missions" in the presence of the other entries and other background traffic driven by stunt drivers. Team MIT came in fourth, largely due to inexperience with dirt roads similar to roads in the first two DARPA challenges in which MIT did not compete. These final events were held at a speed well below that initially described, making the benefit of long-range radar sensing unclear.

This project was a successful collaborative effort between campus and Lincoln Laboratory, which supported the rapid integration of radar sensing capability into Team MIT's Urban Challenge entry.

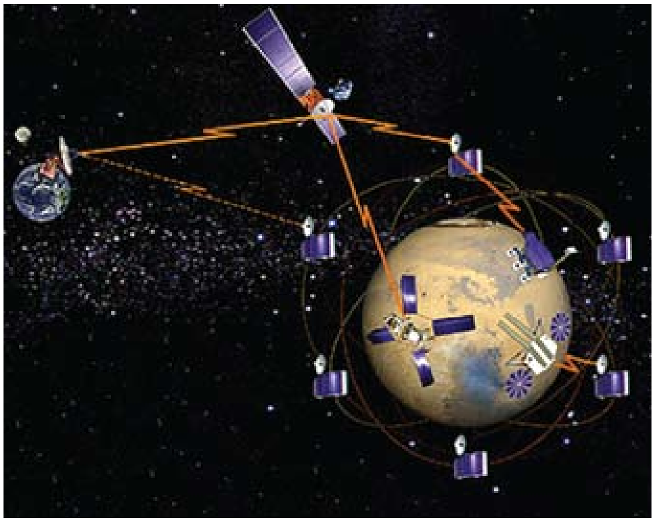
Lincoln Laboratory staff members from the Advanced Capabilities Systems and Air Defense Techniques groups (left to right) Robert Galejs, Jonathan Williams, and Siddhartha Krishnamurthy, worked on the radar techniques for MIT's Urban Challenge vehicle.

Team MIT's Urban Challenge vehicle

TECHNICAL EDUCATION



At the Lincoln Laboratory and MIT Seminar Series, Dr. Barry Burke of the Advanced Imaging Technology Group spoke of supplying charge-coupled devices like this one during a 20-year collaboration with the X-ray astronomy group at MIT's Kavli Institute.



Lawrence Candell, Assistant Division Head in the Aerospace Division, talked at the Seminar Series of the challenges of deep-space optical communications and described the Mars Laser Communications Demonstration Program, with a focus on the ground receiver architecture.

Lincoln Laboratory and MIT Seminar Series

There has been a long and rich history of collaboration between Lincoln Laboratory and research on campus. Over the past year, the Laboratory has broadened these initiatives through two important seminar series.

The Spring Technical Seminar Series at Lincoln Laboratory provides Laboratory staff the opportunity to engage with leading-edge researchers from the MIT campus. In the past year, the Laboratory hosted six invited talks. These included an overview of the Computer Science and Artificial Intelligence Laboratory and an overview of the Electrical Engineering and Computer Science Department. This series also included talks from the Center for Collective Intelligence, the Institute for Soldier Nanotechnology, the MIT Energy Research Council, and topics in brain and cognitive sciences.

A reciprocal Fall Seminar Series on campus provides a forum to extend Lincoln Laboratory's intellectual footprint on campus. This past fall, nine talks provided students and faculty an opportunity to hear about ongoing and emerging work at the Laboratory.

These well-attended seminars have spawned a range of research collaborations, resulting in new technical concepts and funded programs.

Technology Awareness Series

The Technology Awareness Series provides a broad overview of critical national problems and the technologies that may offer solutions. This series of courses is designed to foster creative thinking so that as new technologies emerge, the Laboratory can identify how they can be rapidly integrated into existing systems to yield new capabilities.

The series is built on four objectives:

- Provide a background in current national operational needs
- Provide a background in technologies and methods to integrate these technologies
- Give an overview of the process of innovation and project definition
- Develop a web-based data repository of information and resources for rapid technology assessment and system development

The series includes both mission-centric courses, e.g., Homeland Defense, and technology-centric courses, e.g., Communication Technology. These stand-alone classes run for one or two full days with the second day often being a brainstorming session.

In this first year of the series, courses offered were Foundations of Computer Security, IR Sensors, Mini/Micro UAV, Communication Technology, and Homeland Defense/Security.

During the Technical Awareness Series course on mini/micro UAVs, Dr. Richard Marino of the Active Optical Systems Group addressed technical staff members.

Technical Education — Semester-Length Courses

Lincoln Laboratory offers onsite, semester-length courses taught by senior technical staff members or guest lecturers and designed around the following goals:

- Help Laboratory staff maintain and expand their technical knowledge, skills, and effectiveness
- Encourage technical versatility, breadth, and perspective by extending knowledge and understanding across disciplinary and organizational boundaries
- Acquaint newer personnel with the Laboratory's advanced technology and its technical themes

Courses offered in FY08 were Analog Filter Design (10-week course) and Optical Discrimination (12-week course).

Homeland Security and Counterterrorism Course

Naval War College,
Newport, Rhode Island

The Naval War College and MIT Lincoln Laboratory jointly conducted a course exploring the critical technologies, capabilities, operational concepts, and policies that will influence how the U.S. defends its homeland and deals with threats posed by terrorism. Thirty officers from all branches of the Services and the Coast Guard attended seminars on topics that included port and airline security, cruise missile defense, detection of and response to weapons of mass destruction, and critical infrastructure vulnerability.

Seminar for West Point Cadets

Kevin Kelly of the Net-centric Integration Group addressed West Point cadets about Lincoln Laboratory's airborne test bed program. The cadets participated in a defense technology seminar at the Laboratory with a focus on 3-D lasers, surveillance, and homeland protection.

STUDENT INTERNSHIPS

John Stueve and MIT VI-A student Hana Adinaya of the Advanced Capabilities and Systems Group test drives on a recording test bed.

MIT co-op student Richard Sinn is supervised by Dr. Pablo Hopman of the Advanced Space Systems and Concepts Group while developing the readout electronics for the Multi-Aperture Sparse Imager Video System (MASIVS).

WPI seniors perform structural analysis for vibration testing with Ron Efromson, their Lincoln Laboratory mentor in the Aerospace Engineering Group.

Lincoln Laboratory has a variety of programs offering students the opportunity to gain experience or to further investigate a chosen career path in science, technology, math, or engineering. Two such in-house programs, VI-A Master of Engineering Thesis Program and the WPI Major Qualifying Program, afford students a means to fulfill an educational requirement. Other Laboratory educational programs support student thesis work, research, and presentations at specific universities.

VI-A Master of Engineering Thesis Program

MIT's Department of Electrical Engineering and Computer Science VI-A Master of Engineering Thesis Program matches industry mentors with undergraduate students who have demonstrated excellent academic preparation and motivation. In the past year, ten VI-A students assigned to Lincoln Laboratory were provided first-hand experience in testing, design, development, research, programming, technical planning, and administration. The program offers professional experience in an industrial environment and gives students the opportunity to do a master of engineering thesis with the supervision of both Laboratory engineers and MIT faculty. Students in this program conclude their time at the Laboratory with a presentation of their work. Past presentations have included such topics as "Micromotion Technologies," "Biologically Inspired Matrix Classification," "Radar Tracking System Development," and "An Earth Image Simulation and Tracking System for the Mars Laser Communication Demonstration."

WPI Major Qualifying Program

Worcester Polytechnic Institute (WPI) collaborates with Lincoln Laboratory for its Major Qualifying Program (MQP), which prepares students to be science and technology professionals with real-world training. The qualifying project demonstrates the application of skills, methods, and knowledge of the discipline to the solution of a problem that would be representative of the type encountered in one's career. MQP activities encompass research, development, and application in a particular subarea of the scientific field and provide access to state-of-the-art resources and contacts for future professional work. Sixteen students have successfully completed their programs at Lincoln Laboratory in the past year.

University Cooperative Education Students

Technical groups at Lincoln Laboratory employ students from MIT, Northeastern University, and other area colleges as co-ops to work full time with mentors in the summer and part time while they take courses. Co-ops build prototypes, help solve problems, and test applications in the field. The co-op experience often evolves into post-graduation employment when the student is hired as a technical staff member. The co-op program enriches the Laboratory's base of highly qualified scientists and engineers, reveals the variety of research opportunities at the Laboratory, and provides a hands-on learning environment for the student. In fall 2007, thirty students participated in the Lincoln Laboratory co-op program. Twenty-three students accepted a Laboratory internship in early 2008.

Graduate Fellowship Program

Graduate fellowships are offered to science and engineering students pursuing MS or PhD degrees. While exposing students to the wide array of research and development activities available at Lincoln Laboratory, the fellowship program awards funds to support a Fellow's stipend, supplement a graduate assistantship, or subsidize other direct research opportunities in the final phases of students' thesis research. This program began in 2002 with five schools and has grown to include 13 MS students and 17 PhD students from 11 schools: The Ohio State University, Brigham Young University, Washington University–St. Louis, Clemson University, University of Michigan, North Carolina State University, University of Washington, New Mexico State University, University of Illinois, University of Colorado, and MIT.

Undergraduate Diversity Awards

Lincoln Laboratory established the Undergraduate Diversity Awards to enhance opportunities for women and minorities pursuing bachelor's degrees in engineering and science. The awards take different forms depending upon the choice of the individual school, but include tuition assistance, support for technical paper presentations, and funds for independent research projects. The schools participating are Bryn Mawr College, Howard University, Mount Holyoke College, New Mexico State University, North Carolina Agricultural and Technical University, Smith College, Spelman College, Stevens Institute of Technology, the University of Puerto Rico, and Wellesley College.

Schoolteachers get a 'lift' at MIT Lincoln Laboratory

Program spurs students to pursue scientific careers

January 4, 2008

Lexington High School physics teacher Mark Zagaeski, shown seated, is surrounded, from left, by Lincoln Laboratory scientists Xuan Eapen, Tom Jeys, Simon Hutchinson, and Greg Cappiello.

Dan Gabriner asks students to solve a quadratic equation in his Weston High School class. A voice of discontent issues a challenge familiar to math teachers everywhere: "What can you do with this stuff anyway?"

That's when Gabriner tells his class what he did over the summer. The students are surprised to learn that their teacher worked beside MIT Lincoln Laboratory scientists to produce an algorithm to control airport runway warning lights, minimizing the chance that two airplanes approach the same runway simultaneously. After hearing Gabriner describe his work, the students begin solving equations with new vigor.

To encourage high-school students to pursue careers in science, technology, engineering, and math, Lincoln Laboratory hires local teachers every summer to work alongside seasoned scientists. This public, private, and education sector partnership is possible through the Leadership Initiatives for Teaching and Technology Program ($LIFT^2$), is sponsored by the Massachusetts Department of Education, and is funded through the No Child Left Behind Act.

$LIFT^2$ teachers immerse themselves in various fields, including biotechnology, nanotechnology, information technology, and process manufacturing. Through the five- to eight-week externship, the teachers gain insight into the skill sets needed in a technical profession, thereby enabling them to prepare their students for a career in such a field. Students are more likely to hear exciting real-world uses of science, making a career in science and engineering more desirable and accessible.

Gabriner, mentored by James Kuchar, an aeronautical engineer and assistant leader of Lincoln Laboratory's Surveillance Systems Group, evaluated data for the Runway Status Lights project. He analyzed the scenario of two planes simultaneously approaching a runway intersection at high speed and researched the algorithm logic that controls the warning lights.

Dan Gabriner, Weston High School math teacher (seated, right), works with (clockwise) Maria Picardi Kuffner, James Kuchar, and James Eggert of Lincoln Laboratory's Surveillance Systems Group.

"My teaching style relies on applying math to real-world problems," explains Gabriner. "These stories are more effective when I can say that I used the math myself. The Runway Status Lights project uses multilateration, quadratics, probability, and statistics. I can show my students how each type of math was used to create a system that prevents airplanes from crashing into one another while landing."

The long-term goals of $LIFT^2$ are to entice students to pursue a technical career and help teachers apply information technology to science and math classes. Gabriner says, "After I've had a recent engineering experience, I can develop better projects based on real-world situations … plus, the animations of runway incursions are cool!"

Mark Zagaeski, Lexington High School physics teacher, says he'll draw on the experience of his externship to convey the importance of collaboration in science. Zagaeski was mentored by Tom Jeys, a senior staff member in Lincoln Laboratory's Laser Technology and Applications Group, while working on bioaerosol detection. With a team of scientists, they built a sensor that can detect harmful particles in the atmosphere. "Students often perform alone, but in real-life research situations, people work in teams," he says. "Each team member brings different specialties—they can solve problems together that might be too difficult for one of them alone."

The time at Lincoln Laboratory "reinvigorated my passion for science," Zagaeski says. The $LIFT^2$ Program hopes that enthusiasm is transferred to the students, drawing them into the technical workforce and easing the national shortage of scientists and engineers.

Such an influx of young talent is sorely needed.

According to the Metro Southwest Regional Employment Board, which runs $LIFT^2$, over the past two decades the number of students receiving technical degrees at U.S. universities "has remained unchanged" while "demand for science and engineering workers has grown at four times the rate of the U.S. workforce." In fact, China now graduates six times more engineering students than the United States. By participating in $LIFT^2$, MIT Lincoln Laboratory hopes to strengthen U.S. engineering by leading youths to become the next generation of inventors, scientists, and engineers.

AWARDS AND RECOGNITION

MD-SEA 2007 Jamieson Award

Dr. Benny J. Sheeks, in recognition of his consistently presenting outstanding analyses of radar data.

2008 IEEE Fellow

Dr. David C. Shaver, for leadership in semiconductor microlithography and microfabrication technology.

Department of the Navy Award

William P. Delaney, Director's Office Fellow, was presented with a Superior Public Service Award. The citation was for exceptionally outstanding service as chairman of the Advanced Sensor Technology Executive Advisory Panel from November 1997 to July 2004.

Outstanding Engineering Alumnus Awards

Dr. Antonio F. Pensa, for professional achievements by an engineering alumnus of the Pennsylvania State University.

David R. Martinez, for professional achievements by an engineering alumnus of the New Mexico State University.

IEEE Director-Elect

Roger W. Sudbury has been elected as IEEE Director-Elect for its Division IV, Electromagnetics and Radiation. He will serve as Director-Elect in 2008 and on the IEEE Board of Directors in 2009 and 2010.

Technical Excellence Awards

Dr. Don M. Boroson, for his contributions to the field of modulation and coding techniques as applied to optical communications systems. Dr. Boroson's efforts have transformed this field from one of mainly theoretical interest to one of broad national impact.

Dr. Bernadette Johnson, for her system-level architecting, technical innovation, and prototype demonstration in multiple areas and, in particular, nontraditional problems. Dr. Johnson has applied traditional Laboratory research approaches to novel areas and is nationally recognized in the biodefense field.

2008 MIT Excellence Awards

Fostering Community Award: **Dr. Ronald J. Legere**, *Tactical Defense Systems Group*

Innovative Solutions Award: **Margarita Hiett**, *Space Systems Analysis Group*

Unsung Hero Awards: **James C. Dunn**, *Tactical Defense Systems Group*, and **Gary A. Hackett**, *Human Resources*

Serving the Client Award: The Visitor Reception Services Team consisting of **Roslyn R. Wesley**, **Karen M. Allen**, **Thomas J. Zech**, and **Dollina F.M. Borella**, *Security Services Department*

NASA Group Achievement Award

The Geostationary Operational Environmental Satellite (GOES)-N team—**Dr. Gregory D. Berthiaume**, **Kristin A. Clouser**, **Joshua Model**, **Dr. John O. Taylor**, and **Robert M. Wezalis**—for providing the next generation of advanced weather satellites.

National Aeronautic Association's Robert J. Collier Trophy

Lincoln Laboratory Automatic Dependent Surveillance–Broadcast team, for exceptional achievement in aeronautics or astronautics in America.

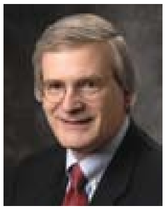
The George Abraham Outstanding Paper Award

Dr. Craig L. Keast, **Dr. James A. Burns**, **Dr. Pascale M. Gouker**, **Richard P. D'Onofrio**, **Antonio M. Soares**, and **Dr. Peter W. Wyatt** from the Advanced Silicon Technology Group for outstanding paper, *Fully Depleted SOI CMOS Technology for Extreme Environments*, at the 2008 Government Microcircuit Applications and Critical Technology Conference (GOMACTech-08).

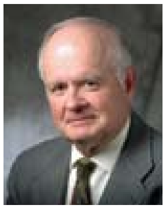
Superior Security Rating

To MIT Lincoln Laboratory's collateral security program from the Commander of the 66th Security Forces Squadron at Hanscom Air Force Base.

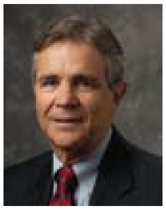
Dr. Benny J. Sheeks



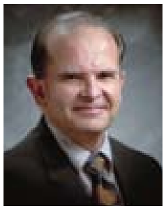
Dr. David C. Shaver



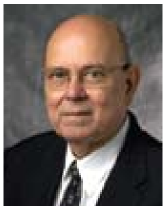
Mr. William P. Delaney



Dr. Antonio F. Pensa

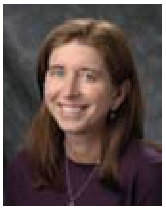


Mr. David R. Martinez



Mr. Roger W. Sudbury

Dr. Don M. Boroson



Dr. Bernadette Johnson

Robert J. Collier Trophy

Patents July 2006–June 2007

"Method and System of Lithography Using Masks Having Gray-Tone Features"
U.S. Patent No. 7,306,881
Michael Fritze and Brian M. Tyrrell

"Incremental Reduced Error Pruning"
U.S. Patent No. 7,305,373
Robert K. Cunningham and Oliver Dain

"Apparatus and Methods for Surface Contour Measurement"
U.S. Patent No. 7,242,484
Lyle G. Shirley

"Multi-channel DPSK Receiver"
U.S. Patent No. 7,233,430
David O. Caplan

"High-Yield Single-Level Gate Charge-Coupled Device Design and Fabrication"
U.S. Patent No. 7,217,601
Barry E. Burke and Vyshnavi Suntharalingam

"Micro-Electro Mechanical Switch Designs"
U.S. Patent No. 7,218,191
Carl O. Bozler, Shaun R. Berry, Jeremy B. Muldavin, and Craig L. Keast

"Apparatus and Method for Isolating a Nucleic Acid from a Sample"
U.S. Patent No. 7,217,513
Lalitha Parameswaran, Albert M. Young, Laura T. Bortolin, Mark A. Hollis, James D. Harper, and Johanna Bobrow

"Optoelectronic Detection System"
U.S. Patent No. 7,214,346
James D. Harper, Richard H. Mathews, Bernadette Johnson, Martha S. Petrovick, Ann Rundell, Frances E. Nargi, Timothy Stephens, Linda M. Mendenhall, Mark A. Hollis, Albert M. Young, Todd H. Rider, Eric D. Schwoebel, and Trina R. Vian

"Device for Subtracting or Adding Charge in a Charge-Coupled Device"
U.S. Patent No. 7,199,409
Michael P. Anthony

"Network Security Planning Architecture"
U.S. Patent No. 7,194,769
Richard P. Lippmann, Chris Scott, Kendra J. Kratkiewicz, Michael Artz, and Kyle W. Ingols

"Interferometric Communication System and Method"
U.S. Patent No. 7,187,871
Sumanth Kaushik

"Self-Assembled Quantum Dot Super-lattice Thermoelectric Materials and Devices"
U.S. Patent No. 7,179,986
Theodore C. Harman, Patrick J. Taylor, Michael P. Walsh, and Brian E. LaForge

"Methods of Achieving Optimal Communications Performance"
U.S. Patent No. 7,181,097
David O. Caplan and Walid A. Atia

TECHNOLOGY TRANSFER

As a Department of Defense Federally Funded Research and Development Center, MIT Lincoln Laboratory is focused on increasing the Technology Readiness Level (TRL) of applicable enabling technologies to support critical new DoD capabilities. An essential element of a sustained research thrust is the demonstration of new systems capability in relevant (field) environments – each thrust is structured to bring the new capability up to the TRL 5-6 range.

At the same time, continuing adaptation of the emerging enabling technologies (at TRL 2-3) assures that the critical national systems expertise is enhanced and sustained, so that additional innovations can be transitioned to the Services and industry as rapidly as possible. A common strategy for achieving transition is to share the "architectural recipe" and work with commercial component and subsystem suppliers to assure that technology readiness demonstrated by Lincoln Laboratory can be duplicated by industry.

The Laboratory contributed foundation technologies to two systems: (1) bioaerosol sensing and microlaser technologies are in commercial production for the Joint Biological Point Detection System (JBPDS); and (2) optical communications technologies used in the GeoLITE free-space optical communications satellite demonstration system are now commercially available for use in follow-on optical communications programs.

Examples of recently transferred technologies:

Devices and materials

- Photon-counting detector arrays
- Orthogonal-transfer charge-coupled-device technology
- Cryogenic laser technology
- Microelectromechanical RF switches
- 193-nm-wavelength optical lithography and immersion lithography technology

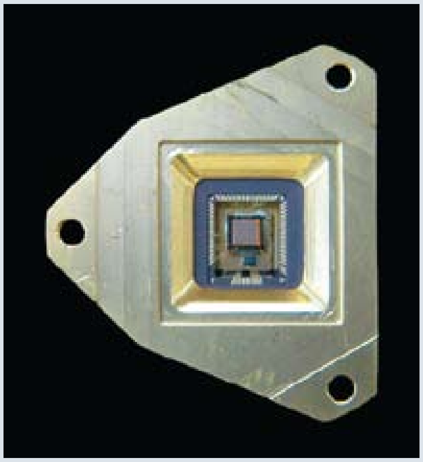
Communications and information assurance

- Low-profile protected SATCOM transportable antenna system
- Multiband (20/30/45 GHz) feed
- Computer network configuration, operations, and vulnerability analysis tools

Sensors and algorithms

- Algorithms and sampling methodologies for sensing explosives
- CANARY rapid bioagent identification technology
- Airborne IED-detection technology
- LADAR and processing technology
- Tracking and exploitation algorithms against dismounts
- Adaptive beamforming and automatic target-recognition algorithms
- Nonlinear equalization receiver technology

Lincoln Laboratory has also worked closely with a number of small businesses on joint technology development programs funded through the U.S. Government's Small Business Technology Transfer Program.



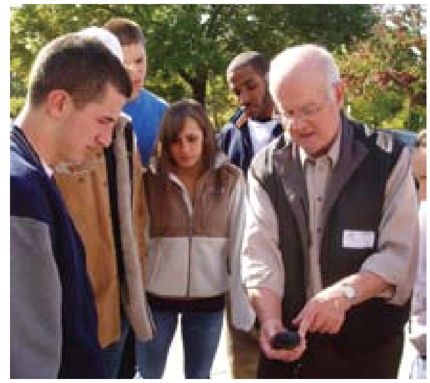
Photon-counting arrays

SATCOM transportable antenna system

COMMUNITY OUTREACH

Community Service and Giving

The Lincoln Laboratory Hike & Bike Tour fund-raising team raised over $5000 for the National Multiple Sclerosis (MS) Society.



Bill Delaney, Director's Office Fellow, presents a Science Seminar on GPS at Belmont High School.

Multiple Sclerosis Hike and Bike Event

As part of the Lincoln Laboratory Community Outreach (LLCO) efforts, Laboratory staff participate in the National Multiple Sclerosis (MS) Society's "Hike & Bike the Berkshires" event. This year, LLCO expanded its involvement in the MS event to include both hiking and cycling teams, totaling 24 members.

Used-Book Drive

In coordination with the MIT Community Giving Fund, Lincoln Laboratory raised over $4000 at a recent week-long used-book drive.

Support Our Troops Drive

Lincoln Laboratory initiated a Laboratory-wide Troop Support campaign. Donations of food, toiletries, books, and games are collected daily, are boxed by volunteers, and are mailed weekly. Lincoln Laboratory Troop Support has sent packages to 93 soldiers during this effort. Currently, 60 soldiers are on the mailing list; the remainder have finished their tours of duty and returned to the U.S. To date, 355 packages have been mailed. This effort has been expanded to include the collection of warm clothing that is sent to Afghanistani refugee and orphan camps.

In the past year, the Laboratory has received five certificates and four American flags flown in honor of Lincoln Laboratory Troop Support, two from Iraq and two from Afghanistan, and an additional certificate from Afghanistan for supporting the orphanages and refugee children.

Educational Outreach

Science on Saturday

This program features onsite science demonstrations by Lincoln Laboratory technical staff. Science on Saturday events have been well attended and are growing in popularity. Over 2220 local K–12 students, their parents, and teachers have enjoyed demonstrations on the principles of cryogenics, magnetism, sound waves, chemistry, optics and lasers, and plasma and ions. A hands-on engineering event involved activities such as building structurally sound towers with gumdrops and toothpicks.

Classroom Presentations

Dr. Todd Rider coordinates a program that sends technical staff members to local schools, giving presentations to students in grades K–12. More than 6000 students have enjoyed presentations on cryogenics, electronic circuits, paleontology, biotechnology, astrophysics, and other topics. In conjunction with this outreach, the Laboratory also conducts tours for local high-school students to provide a behind-the-scenes look at careers in electrical, mechanical, or aerospace engineering; biology; chemistry; materials science; physics; and optics.

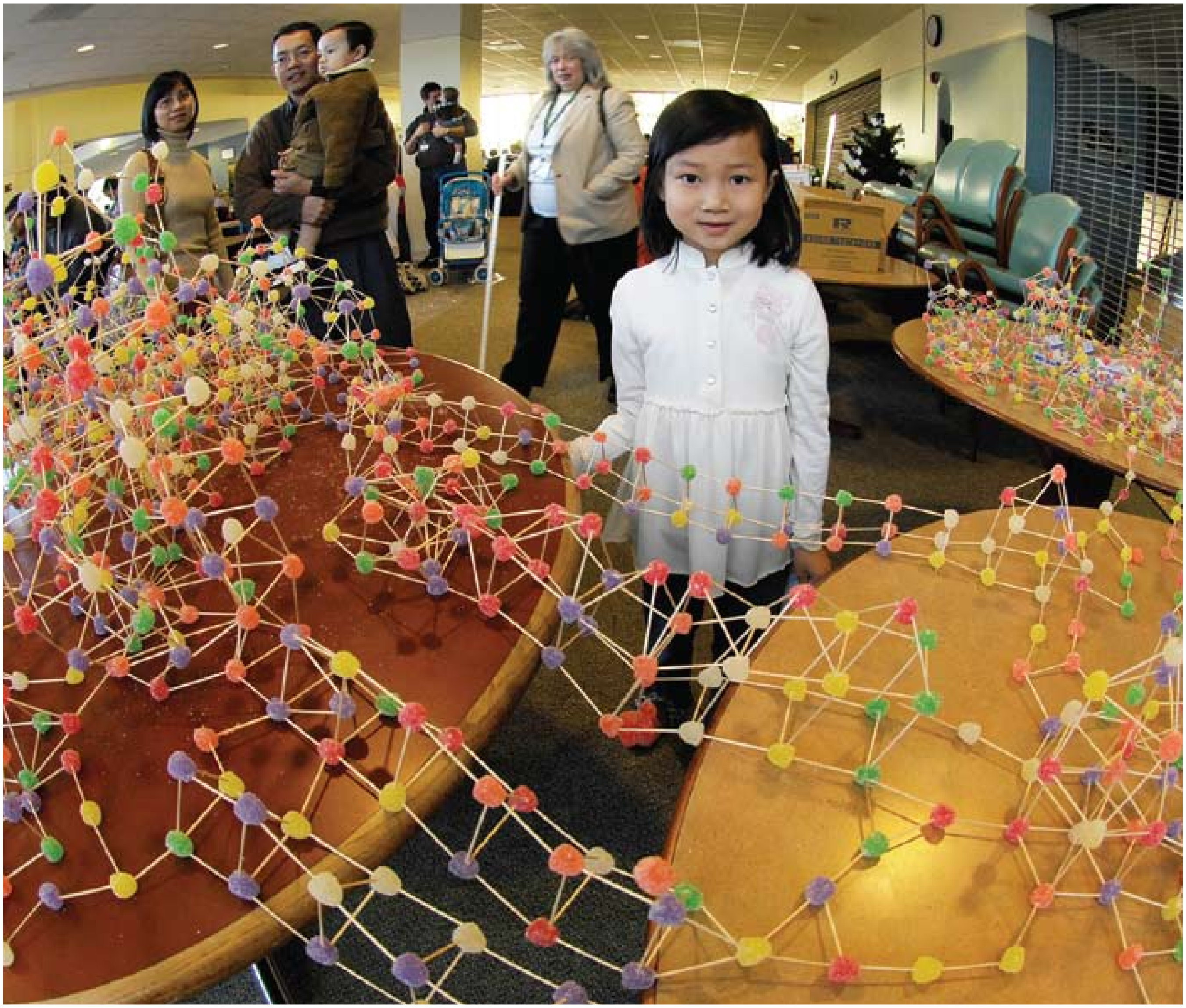
AFCEA International Program

Lincoln Laboratory participates in the Armed Forces Communications and Electronics Association (AFCEA) International Program. AFCEA provides educational incentives and assistance for high-school students engaged in information management, communications, and intelligence efforts while fostering excellence in science. Lincoln Laboratory employed three AFCEA students this year. The program culminated in a tour of Lincoln Laboratory's Microelectronics Laboratory, the Weather-Sensing Facility, and the Biotechnology Laboratory.

Robotics Outreach at Lincoln Laboratory

In 2008, Lincoln Laboratory established a Robotics Initiative—a new educational outreach program designed to stimulate youth interest in science and technology. A part of this program, Robotics Outreach at Lincoln Laboratory (ROLL), seeks to foster a sense of excitement that might drive students towards math, science, and engineering by engaging them in robotics and workshops. ROLL offered a pilot workshop in summer 2008 consisting of a weekend hands-on engineering challenge using Lego Mindstorms to build and program a working robot. Further workshops will be scheduled based on lessons learned from this pilot program.

Education and Community Service



Children and adults tested their architectural prowess by building towers with gumdrops and toothpicks at one of the Laboratory's Science on Saturday events.

Laboratory employees participated in the 5K Fun Run to support Food for Free.

Students operate a robot at a recent Science on Saturday event.

Eric D. Evans, Director, accepts thank you for Lincoln Laboratory's troop support.

MIT LINCOLN LABORATORY ORGANIZATIONAL CHART

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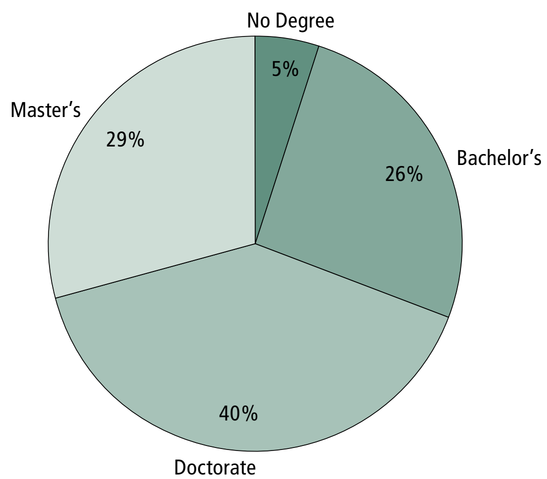
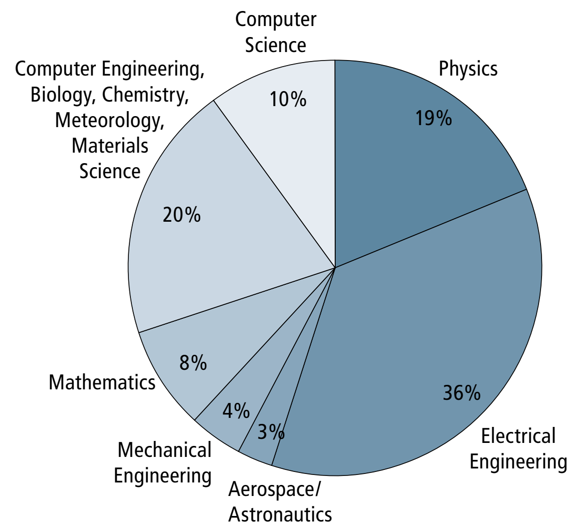
Staff Technical Equivalents:	1,391
Support:	1,075
Technical Support:	161
Subcontractors:	468
Total Employees:	3,095

by Degree

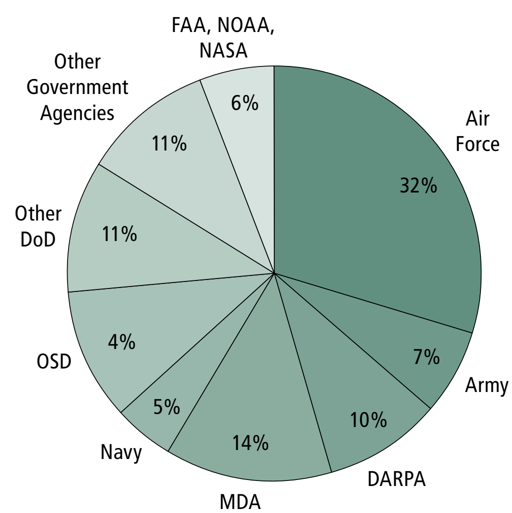


by Academic Discipline

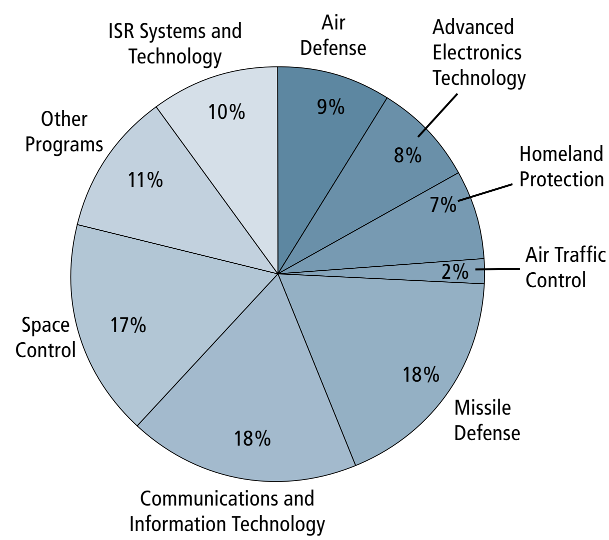


LABORATORY PROGRAMS

by Sponsor



by Mission Area



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Lincoln Space Surveillance Complex, Westford, Massachusetts

Reagan Test Site, Kwajalein Atoll, Marshall Islands

TECHNOLOGY IN SUPPORT OF NATIONAL SECURITY

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